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The musical dimension of Chinese traditional theatre

An analysis from computer aided musicology

Rafael Caro Repetto

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DIRECTORS DE LA TESI

Dr. Manel Ollé

Dr. Xavier Serra

Departament de Tecnologies de la Informació i les Comunicacions

DEPARTAMENT D'HUMANITATS

The thesis' companion web page:
http://compmusic.upf.edu/caro2018thesis

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Abstract

Music, and especially singing, is one of the most important dimensions of xiqu, Chinese traditional theatre. The melody of xiqu arias is arranged by actors and actresses according to an orally transmitted principle known as *shengqiang*. Deepening the state of the art understanding of *shengqiang* as source for melodic creation is the main motivation of this thesis. To this aim, I focus on one of the nowadays most acclaimed xiqu genres, jingju (also known as Peking or Beijing opera), and more specifically, on its two more representative *shengqiang*, namely *xipi* and *erhuang*. The goal of this thesis then is to characterise their melodic identity.

I propose a novel approach based on computer aided musicology. A corpus of machine readable music scores for 92 arias is created, covering 899 melodic lines. Grouped according to the four main elements of the jingju musical system, a comparative analysis is performed on 24 line categories in order to produce melodic schemata that represent each *shengqiang*'s melodic identity. To support and expand these results, a series of computational tools are developed to computationally extract statistical and quantitative information. The corpus, code, and generated data and figures are made openly available in the thesis' companion web page.

The produced melodic schemata are expected to contribute to future musicological and ethnomusicological research by offering a reference for these two *shengqiang* as sources for melodic creation in jingju. And as such, to contribute to the better understanding of jingju as a comprehensive art form for sinological studies.

Resumen

La música, especialmente el canto, es una de las dimensiones más importantes del xiqu, el teatro tradicional chino. Los actores y actrices de xiqu crean la melodía de las arias de acuerdo con un principio de transmisión oral llamado *shengqiang*. La principal motivación de esta tesis es avanzar en la comprensión del *shengqiang* como fuente de creación melódica. A tal fin, tomo como objeto de estudio uno de los géneros de xiqu más aclamados en la actualidad, el jingju (también conocido como ópera de Pekín o de Beijing), y en concreto, sus dos *shengqiang* más representativos, *xipi* y *erhuang*. El objetivo de esta tesis pues consiste en la caracterización de su identidad melódica.

Propongo un método novedoso basado en musicología con apoyo computacional. Para ello he creado un corpus de 92 partituras legibles por máquina, que contiene 899 líneas melódicas. Agrupadas según los cuatro elementos principales del sistema musical del jingju, llevo a cabo un análisis comparativo de 24 categorías de líneas para obtener esquemas melódicos que representen la identidad melódica de cada shengqiang. Con el objetivo de apoyar y expandir estos resultados, he desarrollado una serie de herramientas computacionales para extraer información estadística y cuantitativa. El corpus, el código y los datos y figuras generadas son accesibles a través de la página web que acompaña la tesis.

Con estos esquemas melódicos espero contribuir a investigaciones musicológicas y etnomusicológicas futuras ofreciendo una referencia para estos dos *shengqiang* como fuente de creación melódica en el jingju. Y como tal, contribuir también al mejor entendimiento del jingju como arte ecléctico desde la sinología.

Preface

This thesis addresses one of the most significant dimensions of Chinese traditional theatre: music. Specifically, it focuses on one particular genre and one particular aspect of its musical system. Jingju is arguably the most widespread xiqu—the original term for Chinese traditional theatre—genre not only in China, but also internationally, mostly due to the level of refinement and beauty its visual and aural dimensions achieved. Of the elements that form the jingju musical system, 声腔 *shengqiang*, which provides the basic melodic material, is still understudied on its own in state of the art literature. This thesis then aims at contributing to deepening the current understanding of *shengqiang*, by focusing on the two most representative ones in jingju, namely 二黄 *erhuang* and 西皮 *xipi*, as they are used for the creation of sung melodies, the utmost expression of xiqu music.

Throughout this thesis I will be using the terms xiqu and jingju. However, nowadays there is not a common agreement in English written scholarship about how to refer in this language to the original 戏曲 *xiqu* and 京剧 *jingju* terms. The latter is frequently known in English sources as 'Peking opera,' or 'Beijing opera.' Guy (1995) offers a strong argument for the use of Peking opera. However, the term that troubles me, rather than Peking or Beijing, is 'opera.' Yung pointed out that the use of a specific English term depends on the scholar's field of expertise, so that "[t]he musicologist prefers 'opera' (Pian, Yung), the literary scholar prefers 'drama' (Johnson, Dolby), and the student of theater arts prefers 'theatre' (Scott)" (1989: xii). Indeed, as it can be inferred from his autoreference, since his main interest is musicological, the preferred term by

Yung is 'opera.' More recently, the use of 'opera' has been confronted by both Chinese and English writing scholars. Among the former, Jiang[2] states that the use of 'opera' is "not appropriate" (1995: 2), and Yuan affirms that it is "misleading" (2005: 205). The most common argument, among many others, is that the synthesis of artistic disciplines that characterize xiqu is much more balanced than in opera, which is mainly considered a musical genre. If on stage performers of opera—that is, non instrumentalists—call themselves singers, their analogues in xiqu refer to themselves as 演员 *yanyuan*, actors or actresses. The 中国戏曲学院 *Zhongguo xiqu xueyuan*, one of the most important institutions for training of xiqu performers, translates its own name to English as National Academy of Chinese Theatre Arts (NACTA). Perhaps the boldest claim is made by Lei, arguing that "the English term 'Chinese opera' is a Western invention, not a translation from Chinese" (2006: 9). Stock presents an interesting discussion on this terminological debate (2003: 4–7), concluding to use a romanization of the original Chinese term, with occasional uses of 'opera,' mainly to avoid an excess of Chinese terminology and for stylistic variety. The author refers to pots-colonial thinkers for the strongest argument for his option, when they claim that "use of a Western term is patronizing, in that it suggests incorrectly that the foreign entity can only be approached through the filter of Western experience" (7). Agreeing with this last arguments, throughout the thesis I use the romanized terms to refer to xiqu, the general category of Chinese theatre arts, and to each of each genres, such as jingju. Due to the high frequency of homonymy in Chinese, it might occur that two xiqu genres written with different characters share the same pronunciation and therefore the same romanization, such as 越剧 *yueju* and 粤剧 *yueju*. In order to avoid confusion, and since in most occasions the first lexeme of the term is a toponym, referring to the birth place of that particular genre, I use the translation of this toponym for clarification, so that the two just mentioned xiqu genres are respectively named Shaoxing yueju and Cantonese yueju.

Besides xiqu genres, I use the romanization of Chinese terms when the same aforementioned criteria might apply, mainly in the cases of musical instruments and music theory concepts. In order to avoid an excess of Chinese terminology, English terms are used when they present an equivalent meaning. This is the case of terms such as 'xiqu genre' for 剧种

juzhong, 'aria' for 唱段 *changduan*—the similarities between aria and *changduan* are discussed in Section 4.1, 'play' for 剧目 *jumu* or 戏 *xi*, and 'libretto' or 'script' for 剧本 *juben*, to mention just the most frequent ones. Those romanized terms which are understood as the only possibility for referring to is signified, such as xiqu itself, xiqu genres or musical instrument, are written in regular script, not italics, which are used for terms with a high degree of specificity or which might be accounted for with English phrases, such as *shengqiang*, *erhuang* and *xipi*. Since grammatical number is not morphologically expressed in Chinese, all romanized terms are kept invariable, e.g. 'two *shengqiang*.' At all times I draw on the 汉语拼音 Hanyu Pinyin system for romanization, which is the official one in the People's Republic of China, without the diacritics for marking tone categories. Every time a Chinese term, including the name of Chinese people, institutions or works of art, appear for the first time in the text, I provide its original form in Chinese characters, its romanization and, if applicable, its translation. In the next references of the term, only the romanization is used, but the original Chinese characters can be consulted in the glossary offered in **Annex 1**. All the translations of Chinese terms and quotes from Chinese sources are mine, unless otherwise specified.

Since many of the Chinese authors listed in the **Bibliography** share the same surname, when they are referenced in the text a subindex is added to the surname according to the order in which they are listed. On the other hand, even though Chinese personal names present the surname first, if the author chooses a different order in his or her publications, this order is respected when referenced. Therefore, for instance, $Zhang_5$ refers to the jingju music scholar and composer 张正治 $Zhang_5$ Zhengzhi, whilst $Zhang_1$ refers to the computational linguist, and frequent collaborator of mine, Shuo $Zhang_1$, who signs in this order and not using Chinese characters.

For the research task undertaken in this thesis, a computer aided approach is proposed. This approach is based on corpus-driven methods, which imply the creation of a research corpus and computational tools for the automatic extraction of statistical and quantitative data. Both the corpus used in this thesis and the code developed for its exploitation, as well as the figures and data produced from the undertaken research, are available in the thesis's companion website.[1] The working status of all the links to online sites provided throughout the thesis was verified on September 20, 2018.

[1] http://compmusic.upf.edu/caro2018thesis

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Abbreviations

BJ	Beijing dialect
C	Closing line
C4DM	Centre for Digital Music
CNN	Convolutional Neural Networks
HG	Huguang dialect
HMM	Hidden Markov Models
JaCRC	Jingju a Capella Recordings Collection
JaCRC-1	Jingju a Capella Recordings Collection, part 1
JaCRC-2	Jingju a Capella Recordings Collection, part 2
JARC	Jingju Audio Recordings Collection
JLC	Jingju Lyrics Collection
JMC	Jingju Music Corpus
JMSC	Jingju Music Scores Collection
MBID	MusicBrainz ID
MIR	Music Information Retrieval
MTG	Music Technology Group
NACTA	National Academy of Chinese Theatre Arts 中国戏曲学院
NLP	Natural Language Processing
O, O1, O2	Opening line, Opening line 1, Opening line 2
ODF	Onset Detection Function
S1, S2, S3	Line Section 1, line Section 2, line Section 3
S3.1, S3.2	First and second subsections of line Section 3
SVAD	Singing Voice Audio Dataset
UPF	Universitat Pompeu Fabra
ZZ	Zhongzhou rhymes

Chapter 1 Introduction

1.1. Personal motivation: “opera” without composers

The research presented in this thesis is rooted in a very personal crave for understanding music creation in jingju. During my informal research on this topic, an extremely interesting and absolutely novel for me musical system was being unveiled. However, the descriptions and explanations I found in my readings ended up with some unsolved questions, those that enclose, from what I have been gathering, the very origin of melodic creativity in this art form. Precisely those whose answers would have helped me musically comprehend a jingju performance. As I was acquiring more formal training and theoretical knowledge about Chinese traditional music in particular, and ethnomusicology in general, I realised that those unsolved questions for me might have a broader interest than my own, personal one, since jingju musical system relates to many other theatrical styles, and indeed to other Chinese musical, and even literary genres. I presumed that the answer to those questions might be a contribution to those two fields, musicology on Chinese traditional music, and ethnomusicology. But because of its central position in Chinese traditional arts, I thought that contributing to the understanding of music creativity in jingju will also benefit sinology in general. These believes moved me to engage in the formal research whose process and results are presented in this thesis. However, since all started with those unsolved questions, I would argue that devoting some space to detail this personal motivation might shed light about the decisions taken throughout the research.

My first direct experience with "Peking opera" was, at best, puzzling. It was in the 北京大学百周年纪念讲堂 *Beijing daxue bai zhou nian jinian jiangtang*, Peking University Hall (according to its own official translation),[1] during a stay at that institution in the academic year 2007-2008, and I cannot recall which play it was. Although in occasions I was dazzled by the visual beauty of costumes and movements, it all was lost in a general confusion about the meaning and purpose of everything that was occurring on scene. My limited knowledge of Chinese at that time could barely help me to grasp some clues about the plot in general lines. But without any question, the most incomprehensible aspect of all was the sonic one. From recitation to singing, from the extremely piercing timbre of the 京胡 jinghu, the main accompanying instrument, to the almost disturbing sound mass from the percussion, every element resulted to me unfamiliar, unconnected, unstructured, and therefore, meaningless, i.e., unable to produce in me any meaning. This baffling experience was augmented by the fact that unconsciously, as I recognized a posteriori, somehow I was carrying expectations of enjoying a "Chinese sounding" opera. I had no preconceptions about what that "Chinese sound" might be, in fact, that was precisely what I was eager to discover, since, as an opera lover, I was counting on the operatic conventions to help me unveil their Chinese specificities. But nothing on stage, beyond the fact that it was sung theatre, could be connected with operatic conventions I knew. However, the most shocking experiences did not come from what was happing on stage, but from something I realised in the seat next to mine. An elderly lady was shedding tears of emotion. The same visual and aural objects that were producing in me a feeling of uneasiness were bringing to tears to local aficionados sitting next to me. I needed to understand why.

The most intriguing finding about the music system of xiqu, the general term for Chinese traditional theatre, was its folk nature, according to Chinese musicology. During my first years in China, I took some general courses on Chinese traditional music, and gradually I engaged in a process of disentangling operatic assumptions from the understanding of xiqu and of comprehending it in its own. In this process, I came to realise that the most widespread classification of Chinese traditional music was the one

[1] http://www.pku-hall.com

proposed by 王耀华 Wang Yaohua in 1990 in his work 中国传统音乐概论 *Zhongguo chuantong yinyue gailun* (Introduction to Chinese music) (Yuan 2000: 7). This system classifies Chinese traditional music in four broad categories, namely 宫廷音乐 *gongting yinyue*, court music, 文人音乐 *wenren yinyue*, literati music, 民间音乐 *minjian yinyue*, folk music, and 宗教音乐 *zongjiao yinyue*, religious music, each of them including several sub-classes. This system of four broad classes has been the reference for contemporary textbooks on Chinese traditional music, although with some rearrangements regarding the sub-classifications (Yuan 2000, Zhou 2003, Huang 2007). However, all of them coincide in classifying xiqu as a sub-class of folk music.

The direct implications of considering xiqu music as folk is that it is not created by a composer, but transmitted orally. This realisation was for me the breaking point for the understanding of the nature of xiqu music as independent from opera music. Indeed, when a particular opera is attributed to an author, this generally is the music composer. However, if there is an artist to whom the creation of a xiqu play is related, that would be either the playwright, especially in styles like 杂剧 zaju or 昆剧 kunju,[2] or its main performer, in some occasions associated with a playwright, like is the case of jingju. No specific artist is associated to the creation of the music. In fact, literature about xiqu does not use the term 'composition' (*zuoqu* 作曲) to refer to the process of music creation in this genre. The most common term is 编曲 *bianqu*, literally 'tune arrangement.'

The tune arrangement through which new plays were set to music is based in a series of preexisting music conventions. Xiqu scholars agree on defining two broad systems of these music conventions, and each xiqu genre would use either or both of them for the arrangement to music of new plays. The first and historically earliest one is called 曲牌联缀体 *qupai lianzhui ti*, which can be understood as 'system of sequence of tune labels,' and to which I will refer as system of tune sequences. Although it evolved into a very complex system, depending on the specific xiqu genre

[2] This genre is also commonly known as 昆曲 kunqu. Nowadays the term kunju is preferred to name the genre as whole, stressing its theatrical dimension by using the lexeme 剧 *ju*. Kunqu, formed with the lexeme 曲 *qu* for 'tune,' is used to refer to its musical dimension. (Personal communication by 陈睿 Chen Rui, actor from the 江苏省昆剧院 Jiangsu sheng kunju yuan, Jiangsu kunju company).

that uses it, its principle is quite straightforward. When a new play is created, the arias are written to fit in the metrical pattern of an existing tune, so that it can be sung with the same melody of the original one. Since this tune belongs to a well known repertoire by the lyricists, actors, actresses and musicians, the script only needs to indicate the name of that specific tune, that is, the 'tune label' or 曲牌 *qupai*, before the section of lyrics to be sung, in order to let the actor or actress know how to sing them.

The second system is called 板腔变化体 *banqiang bianhua ti*, which can be understood as 'system of metrical pattern changes,' and to which I will refer as system of metric changes. According to musicological literature, this system is based in one single melodic material that is transformed metrically in order to convey different expressive functions. As a simplified explanation of the system, that melodic material can be performed either in its original form, in slowed down versions, implying a longer metre, in sped up versions, with a shorter metre, or even in free metred versions. These metrical patterns, called 板式 *banshi*, hence, do not determine—although they naturally influence—the original melodic material, which is, according with theoretical formulations, maintained across all these metrical pattern changes.

Both these systems, one characterized by use of *qupai* and the other by the use of *banshi* as main structural elements, share a common principle, the *shengqiang*, which precisely is the focus of the research presented in this thesis. In both systems, *shengqiang* is the element that confers music identity. In the system of tune sequences, where the melodic content is determined by the *qupai*, *shengqiang* establishes the general style, specifying general melodic trends, singing characteristics, and main accompanying instruments. In the case of the system of metric changes, *shengqiang*, besides the same just mentioned aspects, also provides the melodic material that is transformed across *banshi*. This last aspect, the melodic material established by *shengqiang* in the system of metric changes, is the one that, to my understanding, state of the art literature fails to describe in detail.

Jingju is a xiqu genre that uses the system of metric changes for music creation. Consolidated as a new genre during the 19th century, due to several historical reasons jingju adopted a variety of different *shengqiang*, from which two clearly are the most preferred ones, namely *xipi* and *er*-

huang. These two *shengqiang*, conjointly known with the collective name 皮黄 *pihuang*, a contraction of their last syllables, are not used only in jingju. Originated in Southern provinces of China, they spread along the country, giving birth to new genres or being incorporated to existing ones (see Section 4.1). However, jingju artists developed and refined them in a way that they came to represent the music of the genre as a whole. One specially prolific period for the development and expansion of jingju music was the first half of the 20th century, when the greatest performers of this genre where active, such as the *laosheng* actors 谭鑫培 Tan Xinpei (1846-1917), 余叔岩 Yu Shuyan (1890-1943), 周信芳 Zhou Xinfang (1895-1975), 马连良 Ma Lianliang (1901-1966), and 杨宝森 Yang Baosen (1909-1958), or the *dan* actors 王瑶卿 Wang Yaoqing (1881-1954), 梅兰芳 Mei Lanfang (1894-1961), 荀慧生 Xun Huisheng (1900-1968), 程砚秋 Cheng Yanqiu (1904-1958) and 张君秋 Zhang Junqiu (1920-1997), just to mention probably the most influential actors among the many great performers of these period, and only considering the two more relevant role types in terms of singing, namely 老生 *laosheng* and 旦 *dan* (Section 4.3). These actors, as artists with a very distinctive personality, conferred their own imprint to the system of conventions—not only the musical ones—they inherited, creating individual styles and even arranging new plays where to showcase these styles, and consequently founding performing schools that lasted until today.

During the 20th century, jingju spread from Beijing to whole China, becoming one of the most successful and acclaimed xiqu genres across the country. Its influential role in Chinese society was exploited by the political forces that determined contemporary China—and Taiwan. And its artistic qualities called, and are still calling the attention of composers, directors, film makers and artists from all disciplines. Nowadays, it is commonly recognized as a Chinese 'national treasure' (国粹 *guocui*), and even found international recognition when it was inscribed in 2010 on the Representative List of the Intangible Cultural Heritage of Humanity by UNESCO.[3] Ostensibly, understanding jingju music entails understanding one of the most important and influential products of Chinese traditional culture. And concerning jingju music creation, *shengqiang* plays an essen-

[3] https://ich.unesco.org/en/RL/peking-opera-00418

tial role. Achieving this understanding is the personal motivation that moved me to this research, in the hope that its results might contribute to the understanding of wider audiences.

1.2. Scientific motivation: Jingju and computer aided musicology

As a conclusion of the previous brief description of *shengqiang*, it can be understood that this element of the jingju music system is not present in the melodic surface of currently performed—or recorded—singing. The melodic material each *shengqiang* provides is not only transformed by internal factors, that is, other elements of the jingju music system such as *banshi*, but also by external ones, such as the creative personality of generations of artists, just to mention one of them. Consequently, the melodic identity of a *shengqiang* remains an underlying structure, and the study of this melodic identity precisely is the goal of this thesis.

In the state of the art literature about jingju music, the main approach to *shengqiang* is descriptive. Generally, when addressed specifically and not through its combination with a given *banshi*, a series of general characteristics are described in a short text, which usually serves as introduction to more detailed descriptions of its combinations with different *banshi*. These descriptions then are illustrated by examples extracted from actual plays, thus offering the melodic surface from which *shengqiang* can not be directly appreciated. Analytical approaches to jingju music are mostly found in English written literature. However, in most cases, the analyses are applied to very limited samples, and generally focused on one particular *banshi* (for a more detailed discussion of the state of the art, see Chapter 2). The results of these analyses might then not be scalable to a whole *shengqiang*.

The approach proposed in this thesis for the study of jingju *erhuang* and *xipi* is data-driven. If the melodic identity of *shengqiang* is not appreciable in the melodic surface of a given piece, however, it is shared by all the pieces arranged to that particular *shengqiang*. Consequently, the proposed methodology is based in two assumptions. Firstly, identifying the commonalities between all the pieces arranged in one *shengqiang*, and isolating those that are not the result of the influence of other elements such as *banshi* or role type, can produce an approximation to the melodic identity of that particular *shengqiang*. Secondly, the higher the quantity of analysed pieces, the more representative the results can be assumed to be. According to these assumptions, the proposed approach can be defined as the comparative analysis of as many instances of *erhuang* and *xipi* pieces as possible.

As a direct consequence, the research undertaken for this thesis has an important quantitative aspect, for dealing with which I decided to draw on computational tools. Two important goals are pursued with this methodological approach. Firstly, working with machine readable data allows easy and efficient storage, organization, browsing and processing of large quantities of data. Secondly, statistical information can be automatically extracted through computational tools. This statistical, quantitative information is expected to support and expand the results of the comparative analyses, which are to be manually conducted. An important consequence of this methodological approach is that a corpus of data for jingju music research should be gathered, a task which becomes also a goal of the work carried out for this thesis. State of the art research from disciplines such as Music Information Retrieval (MIR) allows more advanced automatic analyses of large collections of machine readable data. However, due to my limited capabilities with computer science, my exploitation of the data can only consist in the extraction of statistical data. These data, as previously mentioned, play an auxiliary role to the central work of manual comparative analysis, by supporting and expanding its conclusions. Therefore, since the use of computational tools do not produce an epistemological shift, the methodological framework for this thesis is defined as computer aided musicology (for a more detailed discussion on this, see Section 3.4).

Consequently, and considering the state of the art research on this topic (Chapter 2), in this thesis I propose a novel approach for the study of jingju music, and more specifically, jingju *shengqiang*, from computer aided musicology. Previous work on this topic was mainly carried out from disciplines such as musicology or ethnomusicology. When researches from computer sciences used jingju music as research object, the purpose of the undertaken tasks usually was to solve a computational research question, for which the use of jingju music data contributes to the evaluation of the proposed solution's scalability, or to the aim of correction the general bias towards Western music traditions in these disciplines. Consequently, the work carried out for this thesis presents itself as an evaluation of the appropriateness and usefulness of the proposed approach for the addressed research task. In that sense, in regard to its methodological framework, this thesis is also understood as a proof of concept for the aforementioned claims that the contribution of automatically extracted statistical and quantitative information to the manually performed manual analysis is valuable and beneficial for the study of jingju *shengqiang*.

1.3. Research environment: The CompMusic project

The research that led to this thesis was carried out within the framework of, and to a large extent encouraged by the CompMusic project,[4] in the Music Technology Group (MTG)[5] from Universitat Pompeu Fabra (UPF),[6] in Barcelona. I was lucky enough to meet the project PI, Xavier Serra, in November 2012, and I started a relationship as assistant researcher from January 2013. It was during this period of collaboration with the team of the CompMusic project when I realised the potential of computational tools for fulfilling the personal motivation described in Section 1.1. I also realised that, contrary to my previous academic experience in the area of humanities, where research is generally carried out individually, in computer science it is common to engage in research collaboratively, even across disciplines. Experiencing this great potential first hand assured me that, even though I had no previous training in or experience in this fill at all, fulfilling the motivation described in Section 1.2 was realistic. Therefore, being conscious that I would have to invest an important time of my research time in achieving a user knowledge of computer science, I decided to propose my doctoral research in the framework of the CompMusic project, and I again was lucky enough to be accepted as a member from September 2013. Since the corpus and technologies used for this thesis were developed in the context of this project, and most of the methodological decisions are related to its principles, I think necessary to briefly introduce it here.

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[4] http://compmusic.upf.edu

[5] https://www.upf.edu/web/mtg

[6] https://www.upf.edu/en

As its very title implies, "CompMusic: Computational models for the discovery of the world's music," this is a very ambitious project, carried out by an international and multidisciplinary team of more than 60 researchers in an academic range from undergraduate to full professor. The central team was based in the MTG, Barcelona, and collaborating teams were located in the Indian Institute of Technology Bombay, Indian Institute of Technology Madras, Bahçeşehir Üniversitesi (Istambul) and Tetouan-Asmir Center (Tetouan). Its remarkable scope has been possible thanks to the support of the European Research Council, who awarded this project with an Advanced Grant (ERC grant agreement 267583) under the European Union's Seventh Framework Program (FP7/2007-2013). The results obtained during its six years of development, from July 1st, 2011 to June 30th, 2017, are published in eight PhD theses, including this one, eight master theses, and more than one hundred papers published in international journals or presented in international conferences.[7]

CompMusic was born from the realisation that music computing research was notably biased towards Western art and popular music genres. This situation creates several problems. In terms of the social value of the results obtained in this discipline, enormous communities of music listeners are excluded from the functionalities and services that the developed technologies offer to the users of the researched music repertories. From a scientific point of view, the discipline ignores a vast portion of its research object, namely music, and consequently all the related research questions, challenges and opportunities. And finally, from a technical point of view, many tasks that are considered as already solved or for which highly satisfactory results are usually obtained might not perform with the same level of accuracy when applied to different music traditions.

The purpose of this project is precisely to tackle this important shortcomings. In words of Serra,

> [t]he main objective of the CompMusic project is to promote and develop multicultural perspectives in Music Computing research. We want to identify music problems coming from culture-specific contexts and work on solutions that might result in new computational methodologies of interest for a wide variety of music information processing problems. (2011: 152)

[7] http://compmusic.upf.edu/publications

In order to achieve these goals, CompMusic draws on several disciplines such as computational musicology, music cognition and human computer interaction (152), but it mostly lies in the domain of the discipline of MIR. Not in vain, as it is stated in the previous quote, the main contributions were achieved in this field, even though notable contributions to other fields were also attained (Serra 2017). In terms of methodology, the project is characterized by two main approaches. The first one is directly inferred from the aforementioned goals, namely culture awareness, which in the field of MIR results in domain specificity. This approach implies that the research tasks and their corresponding methodologies should address and be informed by the specific characteristics of the music tradition researched. The second approach is data-driven research, which implies that the research tasks proposed in the project are solved by analysis of data collected for that aim. This second approach requires the gathering of research corpora created with the purpose of fulfilling such tasks.

The established goals and the proposed methodology as previously described determines the criteria for selecting the research object. On the one hand, it should be comprised by musics for which, an existing, well-established tradition of theoretical literature is available, which informs about their musical characteristics, thus addressing the required domain specifity. On the other hand, these musics should be registered in accessible and machine readable data formats, from which research corpora can be built in order to address the data-driven approach. Consequently, the project focused on five of the world's music traditions that met such criteria, namely Hindustani art music, Carnatic art music, Turkish-Ottoman makam music, jingju music and Arab-Andalusian music. In order to establish a unified research framework that allows to share approaches and insights, and enables cross-cultural studies, the project focused mainly on the melodic (Gulati 2016) and rhythmic (Koduri 2016, Srinivasamurthy 2016) dimensions of these music traditions, but also in more technical issues such as score to audio alignment (Şentürk 2016), lyrics to audio alignment (Dzhambazov 2016) or music ontologies (Koduri 2016).

Finally, an important characteristic of the CompMusic project, and of the MTG in general, is its commitment with open research. Not only all the publications resulting from the research carried out in the project are made available in its website, but also all the gathered research corpora,[8] including data, metadata and annotations, the derived test datasets[9] and the developed software.[10] The aim is to contribute to the scientific community with data and tools for pushing forward the state of the art in the research related to these five music traditions and to computational approaches for their study. With the aim of further contributing to future research, a constant effort is devoted to make all the published work not only openly accessible, but also reproducible. Besides, the commitment to open research is not only made with the researchers and scholars, but to the general listeners of these musics, so that the obtained results are expected to achieve social impact. In this sense, it is worth mentioning Dunya,[11] an online tool for browsing the audio collections gathered in the five research corpora and demonstrate those technologies developed in the project which can enhance the listening experience of the related audio recordings. Dunya has also developed its own API through which the data of each corpus can be access. Besides, the project produced an Android application for enhanced listening of Hindustani and Carnatic art music called Sarāga,[12] as well as a spin-off company, MusicMuni Labs,[13] which developed another Android application that provides exercesies and their automatic assessment for learning Hindustani and Carnatic classical singing.

All the aforementioned characteristics of the CompMusic project had a deep impact in my own research. Methodologically, I propose a data-driven, computer aided approach of the undertaken research task, which in itself is culturally aware. In order to implement this methodology, an important effort was devoted to data gathering, curation and annotation with the aim of building a research corpus for jingju music. And complying with the project's commitment with open research and reproducibility, all the data used for the research presented in this thesis, the resulting figures, plots and data, and the code used for generating them are made available

[8] http://compmusic.upf.edu/corpora

[9] http://compmusic.upf.edu/datasets

[10] http://compmusic.upf.edu/software

[11] http://dunya.compmusic.upf.edu/

[12] https://play.google.com/store/apps/details?id=com.mtg.saraga

[13] https://musicmuni.com/

in the thesis' companion website,[14] and thoroughly documented in order to easy reproduce those results that were computationally obtained.

1.4. Objectives and expected contributions

The general goal of this thesis is to contribute to deepening the state of the art understanding of jingju two more representative *shengqiang*, namely *xipi* and *erhuang*. At the same time, it is conceived as a proof of concept for the proposed novel methodological approach. Consequently, the general goals of this thesis can be broken down to the following objectives.

- According to main goal of the thesis and the proposed approach centred on comparative analysis, the goal is to produce a **schematic representation of the underlying melodic identity that defines both *erhuang* and *xipi***.
- Regarding the proposed methodology, an important objective is the creation of a **corpus for jingju music research** which covers enough data as to grant the representativity of the results obtained from its exploitation, and which allows its analysis from a computational approach.
- Also as a consequence of the proposed approach from computer aided musicology, the development of a **code for the computational extraction of statistical and quantitative information** from the gathered corpus is another important goal of this thesis.
- The expected outcome from the computational analysis of the corpus is a series of **plots and tables with statistical information**. These data are the ones expected to support and expand the information provided by the schematic representations obtained from the comparative analysis.
- Finally, agreeing with the CompMusic project's principles, the corpus, the code and the generated plots and tables will be granted **open access** by their publication on the thesis's **companion web page**. In this regard, the code will be written and documented in a

[14] http://compmusic.upf.edu/caro2018thesis

fashion that ensures the future **reproducibility** of the obtained results.

The achievement of the listed objectives are expected to contribute to the disciplines related to this thesis either because of their research object or characteristic methodology, namely musicology, music information retrieval, ethnomusicology and sinology. These contributions can be specified in the following aspects.

- Regarding its general goal, this thesis aim at contributing to **deepening the understanding of *erhuang*'s and *xipi*'s melodic identity in jingju**. This contribution is expected to offer a ground for future musicological research in terms of jingju music analysis, either of specific plays, or of the style of individual artists or performance schools.
- As a consequence of the previous one, this thesis aims at contributing to **deepening the understanding of the concept of *shengqiang* in general**, specially in jingju, but also as a reference for other xiqu genres in the system of metric changes. Ethnomusicological research might benefit from this for the study of music creation and transmission in jingju in particular and xiqu in general. It is also expected to be a reference for the study of the relationship of music with other artistic disciplines involved in jingju, specially physical acting. Since music is an essential part of such a synthetic art form, the understanding of its own principles, and its relationship with other related domains, is a necessary component for the study of xiqu from sinology. In this regard, the close relationship between music and lyrics renders the understanding of *shengqiang* of utmost importance.
- This thesis also aims at contributing with **openly accessible curated data, metadata and annotations** for the future research of jingju music. These data and related information are expected to contribute to current tasks in fields such as MIR and computational musicology with opportunities for expanding the traditional research object. But most importantly, they are expect to bring to

these fields the opportunity of opening up new research directions.

- Finally, in case the proposed approach might be proven to produce relevant results for the undertaken task, this thesis expects to contribute with a **novel methodological framework for the study of jingju music**. In this case, this thesis aspires at encouraging the use of computational approaches for the research of this music, and therefore contribute to the development of a genuine computational musicology for the study of Chinese traditional music.

1.5. Thesis overview

As explained in Sections 1.1 and 1.2, this thesis is incited by both personal and scientific motivations. The former is grounded in the lack of a satisfactory explanation of the concept of *shengqiang* in the jingju music literature. The latter aims at exploring the possibilities of a novel approach by the incorporation of computational methods to musicological analysis. The **Chapter 2** of this thesis offers a review of the state of the art literature regarding these two aspects, the musicological research on jingju music, and the computational approaches to this musical tradition. As a conclusion of this review, a traditional approach for the description of the jingju musical system is established, which will inform the analysis undertaken throughout the thesis, and a summary of the research corpora created for the study of jingju music is offered.

The detailed description of the methodological framework proposed for this thesis is the content of **Chapter 3**. In the first section, the motivations for considering comparative analysis as the central research method are described, as well as the specific understanding of this method assumed for this thesis. The second section offers a brief report of the fieldwork experience obtained during two research stays in Beijing. The engagement with fieldwork for this research is motivated by my previous training in ethnomusicology and with the aim of exploring the implicit understanding of *erhuang* and *xipi* by contemporary jingju actors, actresses and composers. The outcome of such experience guided the analytical process. In the third section, I describe the functions and goals of the computational tools developed for this thesis. In the concluding section of the chapter, I reflect on the epistemological implications of the proposed methodological approach.

The melodic surface of jingju singing is the result of the interaction of many factors, of which *shengqiang* is just but one of them. Understanding the influence of each of these factors in the melodies that will be analysed is essential in order to discriminate the features related to *shengqiang*. **Chapter 4** presents a detailed and thorough description of each element of the jingju musical system. The first consideration is the relationship of the musical dimension of jingju with the rest of disciplines that form this synthetic art form. The specific relationship of singing with other sonic and musical elements, such as the instrumental accompaniment, is also analysed in this first section. As a theatrical art form, the lyrics have a direct influence in jingju singing, both in terms of structure and prosody, as it is discussed in the second section. The system of role types is presented in the third section, with a special focus on its implications for singing. The core of the chapter is the fourth section, where *shengqiang* is addressed. After a description of the concept in its broader sense, the section focuses on the discussion of jingju *shengqiang*, paying a special attention of how *erhuang* and *xipi* are described in the state of the art literature. The fifth section completes the analysis of the jingju musical system with a description of *banshi*. In the conclusions of the chapter, the main elements that will be consider in the analysis are specified.

Chapter 5 presents the corpus created in the CompMusic project for jingju music research. Each of the four first sections of the chapter describes the four collections of the corpus, respectively containing commercial audio recordings, machine readable music scores, machine readable lyrics and *a cappella* audio recordings. Each collection is described according to the five criteria established in the CompMusic project for the evaluation of research corpora, namely purpose, coverage, completeness, quality and re-usability. In the final two sections of the chapter, I present several test datasets created for different research tasks related to jingju music, and some concluding remarks.

The next two chapters of the thesis present and discuss the results of the analytical work. The brief **Chapter 6** is devoted to the analysis of the relationship between the linguistic tones of the lyrics and the sung melody.

As previously discussed in Chapter 4, this relationship has a direct influence in the melodic surface, whose effect might alter the characteristics of the *shengqiang*. Since the corpus contains annotations regarding the tone categories of the lyrics, a statistical analysis of this relationship is performed in order to contribute with empirical data to the topic. The first section of the chapter presents and describes the code developed for this task, and the next two sections discuss the results for the two relationship types considered in the analysis. In the conclusions of the chapter, I discuss the implications of this aspect for the melodic analysis.

The main contribution of the thesis is contained in **Chapter 7**, which presents and discusses the results of the comparative analysis, with the contributions of the computationally extracted statistical data. The first section describes the criteria for the implementation of the analysis and the characteristics of the melodic schemata resulting from it. The second section introduces the code developed for the extraction of the quantitative data, and explains how the code was used in this thesis for the computation of the figures and tables contained in **Annex 2**. The third section presents the melodic schemata resulting from the analysis of the 24 line categories, defined by all the possible combinations of the instances of the four elements of the jingju musical system, namely role type, *shengqiang*, *banshi* and lyrics structure. In the conclusions of the chapter, These schemata are compared with each other in terms of their common *shengqiang*, in order to obtain a schematic representation of the melodic identity of both *erhuang* and *xipi*.

In the conclusions of the thesis, presented in **Chapter 8**, after a general summary of the thesis, I present the contributions that are expected to have been achieved with this work, and also discuss some limitations of the present approach. In the second section I point towards future research directions that the research carried out in this thesis might open up. To conclude, I offer some final reflections on the concept of *shengqiang* compared with similar principles for melodic creation from other music cultures, specially those also studied in the CompMusic project, with the aim of putting in value the contribution of *shengqiang* to the human wealth of systems and principles for music creation.

Chapter 2 State of the art

As explained in Chapter 1, the main goal of the present thesis is to deepening the understanding of jingju two main *shengqiang*, especially regarding its melodic dimension. To that aim, a novel approach is proposed, whose methodology is understood as computer aided musicology. In the present chapter, I present an overview of the state of the art on the addressed topic from the point of view of the two main components of the methodological framework. In the first section, I review the musicological research about jingju music, paying special attention to how it is usually studied and how *shengqiang* is generally explained. This review pays also attention to the different approaches by Chinese and English academies, and explores the motivations for such differences. The second section of the chapter explores the previous work related to the second component of the methodology, namely the use of computational tools. A review is offered about computational approaches to the study of jingju music, and the research tasks for which this work is carried out. Since an important expected contribution of the present thesis is the creation of a corpus for jingju music research, special attention is paid to the existing databases and their accessibility. The chapter finishes with the conclusions extracted from this review of relevance for the present thesis.

2.1. Musicological research on jingju music

According to the encyclopedic work *Zhongguo jingju shi* 中国京剧史 (Chinese jingju history, Ma 1999), academic research about jingju started during the second decade of the 20th century, with the first journals and magazines, and the first monographs about it, from which the work by Qi Rushan 齐如山 (1875-1962) stands out. Although many of these early works address every aspect of this genre, the widest concern is about its history, renown troupes and famous performers. Promoted by the "New Culture movement" (新文化运动 *xin wenhua yundong*), many intellectuals engaged in a national debate about the reform of xiqu in general, and jingju—which by that time had already achieved a national recognition—in particular, to adapt it to the new ideological needs, a debate that intensified during the Second Sino-Japanese War (1937-1945), when the intellectuals promoting a reform in traditional xiqu thought that these changes were more needed. This debate superseded the academic research on other elements of xiqu. However, it was with the foundation of the People's Republic of China when specific institutions were created for xiqu research. Arguably the most influential institution was the 中国戏曲研究院 Zhongguo xiqu yanjiuyuan, Research Institute for Chinese Xiqu, funded on April 3rd, 1951, and that will evolve into the contemporary NACTA. It was also during that period that music conservatoires became official institutions for music education, and music research was an important activity within them. Chinese traditional music was an important focus of research, and national work of recording, transcribing, publishing and analysing was promoted. Equally, a curriculum for music theory and musicology students was being developed, including courses on traditional music in general, and xiqu music in particular.

A good example of such courses and the academic presentation of xiqu music analysis is the monograph *Zhongguo xiqu yinyue* 中国戏曲音乐 (Chinese xiqu music, 1995), by Prof. Jiang$_2$ Jing 蒋菁, who taught in the musicology department of the 中央音乐学院 Zhongyang yinyue xueyuan, the Central Conservatory of Music, which is considered the most respected institution for music higher education in China. In this book, the author compiles the material that she had been using in the course of the same name that had been teaching from the early 60s, and since then it becames a standard textbook for the matter. Consequently, the ways in which xiqu music theory is presented in this volume is highly representative of the academic knowledge about this issue at the end of the 20th century. After a general introduction to xiqu in the first chapter, where Jiang$_2$ presents a brief historical account (as stated previously, history has been a main trend in xiqu research) and a theoretical definition to the art form itself, the second chapter offers a general overview of xiqu music, presenting the characteristics of singing and instrumental accompaniment, the function of music within the overall genre, the folk origins and posterior professionalization, and its conventionalized nature. Besides, Jiang_2 gives the criteria she followed for the following structure of the book, which is the one also commonly found in other textbooks that offer a general overview of xiqu music (Yuan 2000, Zhou 2003, Huang 2006). For the classification of the xiqu genres, Jiang_2, and other authors, uses two elements. The first one is the music structure system, that is, either the system of tune sequences, based on *qupai*, or the system of metric changes, based on *banshi*. The second one, is a term that according to Jiang_2 was coined in the 50s (35) and has been commonly used since then: *shengqiang xitong* 声腔系统, literally, '*shengqiang* system.' During its historical development, a particular *shengqiang* was carried by troupes, performers or aficionados along their travels. When it arrived to new areas, it could be adopted locally to form a new xiqu genre or added as new component in an existing one. Even though each genre would have developed the original *shengqiang* in its own terms and stylistic preferences, all these local, specific formulations of one original *shengqiang* form a *shengqiang* system (Section 4.4).

In Jiang_2's work, jingju is the xiqu genre that exemplifies the *pihuang shengqiang* system from the system of metric changes, and the way of presenting its music is the one generally followed by jingju music researchers. Firstly, an introduction is given concerning general aspects, including historical notes, the structure of the lyrics, which influences the melodic structure, and a presentation of the different *shengqiang* used in jingju. In a volume like this one, where jingju is a chapter of a comprehensive introduction to xiqu music, a general introduction about *pihuang* is also offered. Jiang_2 also does some interesting remarks about the "scientific" improvements made in jingju to adapt the melodic material to different role types. After this general introduction, the rest of the explanation proceeds *banshi* by *banshi* in each *shengqiang*. It starts with the *banshi* called 原板 *yuanban* in *erhuang* as sung by the *laosheng* role type, which receives an extensive explanation. Then the rest of *banshi* in this *shengqiang* are presented as related to *yuanban*, and then all of then as sung by the *dan* role type. Some brief remarks about a *shengqiang* derived from this one, known as 反二黄 *fan'erhuang* close this section. Next, the same procedure is repeated for *xipi* starting from *yuanban* for *laosheng*, which receives a closer look, and relating the rest of *banshi* to it. If follows some remarks about the *shengqiang* derived from *xipi*, called 反西皮 *fanxipi*, and the chapter concludes with a brief presentation about the rest of *shengqiang* used in jingju. As for the explanation of each *banshi*, it consists on a verbal description illustrated with a sample score[1]. The explanation mostly concerns metrical features, melodic structure, as related with the lyrics' one, and few notes about melody, especially cadential notes. The presentation pattern here described about Jiang$_2$'s work is the one commonly followed in most of the publications by Chinese scholars: general introduction and explanation organized per *banshi*. These are grouped by *shengqiang*, starting from *erhuang*, then *xipi*, and finally the rest, and the first *banshi* to be explained is *yuanban* for *laosheng*, the rest being explained in relationship with this one.

Two of the most influential jingju music textbooks are the ones by Liu$_1$ Jidian and Zhang$_5$ Zhengzhi, whose relevance might be derived from the importance and recognition of their authors in jingju recent history. Liu$_1$ Jidian (1919–2014) is an acclaimed composer of jingju modern plays (现代戏 *xiandai xi*) as well as new historical plays (新编历史剧 *xinbian lishi ju*), having participated in the music composition team of such famous plays as *Bai mao nü* 白毛女 (*The white haired girl*) and *Hong deng ji* 红灯记 (*The legend of the Red Lantern*). His *Jingju yinyue gailun* 京剧音乐概论 (Introduction to jingju music, 1992) is a general compendium of all the aspects related to music in jingju. The book is divided in two parts, the first one devoted to instrumental music, which presents the repertoire performed by the instrumental ensemble solo, without participation of singing, and the second one devoted to the music of arias, focused on the singing part, but including also some references to the instrumental accompaniment. I will focus here in this second part, since it is the one related to my research. Liu$_1$ follows the explanatory thread already described in Jiang$_2$'s work. The part opens with some introductory chapters,

1 Jiang$_2$ generally uses 简谱 *jianpu* (footnote 7 in Chapter 4) for aria fragments, but staff notation for charts and schemata

mostly related to linguistics aspects, some of then affecting the melodic structure, such as tonal categories or lyrics structure, and others affecting performance, like pronunciation or rhyme. The remaining of the part is divided in thirteen sections, each of them devoted to a specific *shengqiang*, in this order: *erhuang*, *fan'erhuang*, *suona erhuang* 唢呐二黄, *xipi*, *fanxipi*, *nanbangzi* 南梆子, *sipingdiao* 四平调, *chuiqiang* 吹腔, *gaobozi* 高拨子, *nanluo* 南锣, *wawa* 娃娃, inserted tunes (插曲 *chaqu*) and miscellany (杂腔小调 *za qiang xiao diao*). In the case of *erhuang* and *xipi*, by far the most extensive sections, the presentation is structured in *banshi*, starting with its use by the *laosheng* role type, and then moving to other role types, including always *dan*, and depending on the case, also 净 *jing*, 老旦 *laodan* or 小生 *xiaosheng* (Section 4.4). The remaining *shengqiang* are not presented according to *banshi* because as secondary ones, proportionally much less used than *xipi* or *erhuang*, most of them are conceived as only presenting one single melodic material. In fact, one of the developments that jingju composers of the 20th century sought was precisely the expanded use of *banshi* for *shengqiang* that previously did not use them.

Focusing now on the *erhuang* and *xipi* sections, each of them starts with a brief paragraph that presents the general features of the *shengqiang*, and then moves forward to the first *banshi*. The presentation of each *banshi* follows a similar structure to the one used by Jiang_2, starting with an explanation mostly focused on melodic structure and cadential notes, and then giving some example arias. Differently from Jiang_2's work, where the examples consist in fragments, generally of one or two lines (although a collection of full arias for different xiqu genres is provided as an appendix), Liu_1 offer full arias as example. Each aria is then followed by short comments that mostly point out the deviations from the general observations made earlier. Consequently, Liu_1's work, in terms of content and method, can be taken as an expansion of Jiang_2's model,[2] since his volume is a monograph exclusively devoted to jingju music.

Following the previous trend, the work by Zhang_5 Zhengzhi can be considered as a step further in terms of detail and extension of explanation

[2] Even though Jiang's work was published after Liu's volume, both of them are the result of their authors long teaching experience, and therefore their origins might be conceived as much earlier than their publication dates.

of the singing melody in jingju music. $Zhang_5$ Zhengzhi (1931) is a xiqu researcher and an acclaimed composer of jingju new historical plays. In his extensive volume *Jingju chuantong xi pihuang changqiang jiegou fenxi* 京剧传统戏皮黄唱腔结构分析 (Analysis of the structure of the *pihuang* singing in jingju traditional plays, 1992), the author offers a detailed description of jingju two main *shengqiang*, which precisely are the focus of my research, namely *erhuang* and *xipi*, as well as the two ones derived from these, *fan'erhuang* and *fanxipi*. In a more recent and brief publication, *Jingju chuantong xi fuzhu qiangdiao jiegou fenxi* 京剧传统戏辅助腔调结构分析 (Analysis of the structure of the auxiliary *qiangdiao* in jingju traditional plays, 2006), $Zhang_5$ completes his previous work with the explanation of four secondary *shengqiang*, such as *nanbangzi*, s*ipingdiao*, *gaobozi*, and *chuiqiang*. I will focus here on the first of these publications, since it is the one most related to my research.

Although the degree of detail is much higher in $Zhang_5$'s work, the train of thought is the same as in the case of $Jiang_2$'s and Liu_1's. The volume starts also with some introductory chapters, and then is divided in four parts, one for each of the studied *shengqiang*, which are then structured per *banshi*. $Zhang_5$'s introductory section is much more musicologically oriented that the ones by $Jiang_2$ and Liu_1. The author gives some personal insights about melodic principles and modal characteristics of jingju music. However, his most important contribution arguably is the analysis of and emphasis on melodic structure and aria form. Already in the introduction, the author sets the importance of the lyrics couplet as the basic melodic structure, and its opening and closing line as the basic melodic units. He also devotes one section to classify arias in terms of their form, regarding the use of one or several *banshi*, and other not sung elements. In keeping with this emphasis on structure, the presentation for each *banshi* follows the same schema of four sections. First, the standard melodic form for each line of the couplet is presented separately. Then, the second section lists possible transformations of this standard form. The third one describes two specific transformations of the standard form, called by $Zhang_5$ 转句 *zhuan ju*, 'turning line,' and 结束句 *jieshu ju*, 'finishing line.' And the final fourth section analyses different aria forms according to the number of couplets. In the analysis of *erhuang yuanban*, which is the first *banshi* analysed, $Zhang_5$ presents five pairs of line types, labeled with capital and lower case Roman letters. Using these labels, the author then presents the possible line combinations in single couplets. In the remainder of the section, Zhang$_5$ selects a series of sample full arias of different lengths, and analyse them in terms of these line types, so that the resulting analysis consists in labeling each line, plus some specific comments, mostly concerning cadential notes. In each of these four sections, each element is described separately for *laosheng* and *dan* role types. Although the approach results in some occasions too constrained for such an organically progressing melodic stream as the one present in many jingju arias, it is undoubtedly the most thorough study of jingju melody structure published to date, and as such is one of the reference textbooks used by jingju music composition students in institutions such as NACTA.

From the sources here presented, their representativeness among jingju specialists, and what they entail as a result of a lengthy teaching experience, it can be argued that Chinese musicology has developed an own tradition for describing jingju music. According to this tradition, the unit for description is the *banshi*. They are presented grouped per *shengqiang*, in an order that starts by *erhuang* and then *xipi*, usually each of them followed by their related *shengqiang*, *fan'erhuang* and *fanxipi*, and finally the presentation concludes with the secondary *shengqiang*. For each *banshi*, a verbal description is offered first, which is then illustrated with a sample aria, either a fragment or a full one. This explanation in each *banshi* is made at least for the *laosheng* and the *dan* role types. All this is usually preceded by some introductory remarks, that usually presents topics related to jingju history or the relationship of melody with the lyrics, both in terms of structure and pitch changes—due to tonal categories. The generalizabilty of this model can be observed in the entry for jingju music ("jingju" 1999) in the Beijing volume of the *Zhonguo xiqu zhi* 中国戏曲志 (Chinese xiqu records) from the colossal *Zhongguo minzu minjian yinyue jicheng* 中国民族民间音乐集成 (Folk music anthology of Chinese nationalities).[3] This entry, whose goal is to provide a general introduction to jingju music, follows the structure just described, offering full aria scores as examples.

[3] For a thorough report on this anthology, please refer to Jones (2003).

The arguably most comprehensive presentation of the jingju musical system written in English, namely the work by Elizabeth Wichmann *Listening to Theatre: The aural dimension of Beijing opera* (1991), should be presented along this Chinese tradition. In this pioneering work, in terms of its general scope and systematic presentation, the author introduces all the different sonic elements of jingju, starting from a formal point of view, describing the structure of jingju lyrics and the principles of the musical system, and moving to more performative considerations, such as the process of music arrangement, vocal techniques for both singing and reciting, and some remarks on instrumental music. This work is the result of a long field research carried out by Wichmann in China, where she also was trained as an actress. As a result, the theoretical structure of the volume reflects the principles previously described in the works of Jiang_2, Liu_1 and Zhang_5. The main difference from these works consists in the fact that Wichmann presents *banshi* separately from *shengqiang*—although she does not use this term as such—what allows her to offer a higher level description of both these entities. However, the presentation method is the same as the one used by the Chinese scholars, consisting in a verbal explanation—much longer in Wichmann's work—illustrated with sample fragments from selected arias—much shorter in this English volume. Regarding the description of *shengqiang*, it follows the same elements present in the Chinese works described, such as metrical principles, cadential notes and differences between *laosheng* and *dan* role types. Consequently, it can be argued that Wichmann's work does not present new insights about these topics, but it reformulates the main scholarly tradition from Chinese musicology on jingju music in order to present it to an English speaking readership.

Regarding the objectives of the present research, this approach to the description of jingju music shared by the previously mentioned works, lacks an essential element, which is a melodic analysis towards inner structures. As mentioned previously, all the music examples used in those works are actual arias from actual plays, in most occasions as sung by a specific performer. Regarding inner, abstract entities as the musical conventions that form the jingju music system, these examples can only work as an illustration of a concept or argument explained verbally, but not as a representation of the concept or the argument themselves. Such representations can only be provided by analytical procedures that present the essential components of the concept or argument in a generalizable, abstract manner. Such analyses are usually provided for the inner metrical structure that defines a *banshi*. These metric schemata (Figure 5) inform about the number of measures usually needed for singing an opening or closing line in that *banshi*—and for specific *shengqiang* and role types—how the singing and instrumental accompaniment parts are distributed in the line, and in which positions should each character be sung. Having these schemata as a basic representation of the *banshi*, example arias illustrate either the norm or related deviations. From these representations it can be observed that the fundamental elements of a *banshi* from the point of view of a jingju performer are the metrical anchors for delivering a lyrics line in singing. Such schematic representations, however, are not offered for melodic elements such as *shengqiang*, and the analytical work in this domain is very limited, besides pointing out the preferred cadential notes for each section of the sung line, the melodic range for each role type, and the relative tuning of the two strings of the jinghu—that is, not the absolute pitch value, but the scale degree to which each string is tuned to—for each *shengqiang*, besides other general remarks about melodic progression. To illustrate the relationship between two *banshi*, or the same *banshi* sung by two different role-types, Jiang_2 occasionally aligns two aria fragments (1995: 227-229, 235-236, 255, 258-259), but she leaves the analysis to the reader. Wichmann (1991) provides a "basic melodic contour" for both *xipi* and *erhuang*, and for both *laosheng* (80), and *dan* (87). However, the author does not indicate if these basic melodic contour is the result of her own analysis, or learnt from her teachers or informants as a common knowledge in jingju circles. She also aligns different aria fragments to illustrate different aspects, like the differences between role types (57-58, 87), line types (60), *banshi* (65, 67, 93-108) or the basic melodic contour and an actual aria (81-82), but, as in the case of Jiang_2, she does not perform any analysis of how they are related. In any case, these analytical attempts are only focused on one single example, what in the case of such inner structure as *shengqiang* might lead to a biased representation.

There are a couple of reasons that might explain why such analytical work is not present in these publications. Reviewing ninety years of research on linguistic tones in jingju, Xu Zheng (2007) realises that, despite the long research history, scholars have not come to an agreement yet. In the concluding remarks, the author points out that a possible reason for such outcome might be that "for most [of the scholars, the knowledge about this topic] is obtained through personal experience, and this experience is obtained by listening and imitating [the singing]" (49). In the case of *shengqiang* research this might be also the case. A textbook published for undergraduate students of NACTA by one of its faculty members, Cao Baorong, with the promising title of *Jingju changqiang banshi jiedu* 京剧唱腔板式解读 (Deciphering *banshi* in jingju singing, 2010), consists in a collection of full arias, organized in the same manner as the previously referenced works: each of the two volumes is respectively devoted to the two main *shengqiang*, *erhuang* and *xipi*, including their derivations *fan'erhuang* and *fanxipi*, and each volume is structured in single sections per *banshi*. In each of these *banshi* sections, a brief text introduces general aspects about the specific *banshi*, and the remainder is a series of music scores of full arias for different role types, with occasional comments by the author after some specific cases. The author explains in the foreword that this publication results from the materials she used in a postgraduate course entitled 京剧声腔概论 *Jingju shengqiang gailun*, Introduction to jingju *shengqiang*, in which the learning method consisted in letting the student memorize a series of arias that exemplify the theoretical concepts, so that they can approach them by listening to and trying to sing them. Indeed, the concept of learning by 'imitative singing' (模唱 *mochang*)[4] is basic in traditional music courses in the Chinese higher education system. I have experienced this method myself during my studying and research stays in different Chinese universities (Section 3.2). As a consequence, the knowledge that jingju specialists have of *shengqiang* is a performative one —what Stock (1999) calls 'practical consciousness—and not a theoretical one. Some actors, when asked about *xipi* and *erhuang*, will just answer (after a roll of the eyes) by humming some characteristic melody—usually from the instrumental introduction.

A second reason for the lack of analytical work in this Chinese musicological tradition on jingju music might be the purpose for which it was

[4] This method is called 'imitative' since the goal is not to render a complete performance, in terms of voice quality, register or intonation proficiency, but one that contains the melodic and performative elements that characterizes the piece under study.

conceived and developed. When discussing the formation of jingju music theory, Jonathan Stock claims that

> mainland Chinese music scholars work in an environment that has for some decades emphasized applied music research. In other words, rather than being primarily concerned with the reconstruction of historical creative practices, a major focus of their research has been the uncovering of principles that can assist contemporary composers and arrangers in the task of setting new operatic texts to traditional melodic materials. (1999:202)

Indeed, as mentioned earlier, the authors of two of the most influential jingju music textbooks, Liu_1 Jidian and $Zhang_5$ Zhengzhi, were themselves composers, and taught composition. In $Zhang_5$'s work, the usefulness of his aria structural analysis for composition purposes is quite evident, and in fact, it is currently used as a textbook for jingju music composition students at NACTA. An explicit textbook for xiqu music composition published by the composer and the NACTA faculty member Zhu Weiying (2004) follows exactly the same tradition for the explanation of the music characteristics of jingju and other xiqu genres from the system of metric changes. Being these the goal of this research tradition, as long as the reader, the student, is able of acquiring a practical consciousness, or a performative knowledge of the concepts explained, the purpose is fulfilled. And to this aim, the listening and imitative singing method is of the upmost importance.

Yu Huiyong (1926-1977) was one of the most relevant composers of jingju modern plays, participating in the composition of such influential works as *Haigang* 海港 (On the docks), *Zhi qu Wei Hu Shan* 智取威虎山 (Taking Tiger Mountain by strategy), or *Dujuan Shan* 杜鹃山 (The Azalea Mountain), and even holding the position of Minister of Culture from 1975 to 1976. His study about the relationship between lyrics and melody in Chinese traditional music (2008) was explicitly written with the aim of helping composers to "consciously master the traditional principles" (6) of setting lyrics to music. After investing nearly fifty pages explaining the principles for composing melodies that respect both the musical system and the linguistic tonal categories, as well as all the possible complications that the composer might come across and how to solve them, Yu reaches a point in which he acknowledges that in some occasions the composer can just break the rules without compromising the intelligibility of the lyrics. To know when and how the rules can be broken, the author suggests to the composer to "meticulously sing [the composed melody] him or herself, dispassionately listen [to it], then let someone else to also sing and listen, and if [both] think that there is no problem, then in can be settled" (62). Consequently, the description and presentation of the jingju music system by the Chinese musicology tradition fulfils its purpose of training jingju composers, inasmuch as they give the basic structural cues for setting the lyrics—which is the raw material upon which the author creates its music—in the *banshi*'s metre, and also offer examples from real arias which the trainee should memorize, 'imitative sing' and listen to, in order to acquire the performative knowledge of the melodic elements.

Analytical approaches to the melodic dimension of jingju music are however common among scholars from Europe and USA. The most significant of these studies for my research, insofar it addresses similar research questions, is the work by Gerd Schönfelder *Die Musik der Peking-Oper* (1972). The goal of Schönfelder's research is to elicit the *melodische Gerüstgestalt*, the 'melodic schematic contour,' of both *xipi* and *erhuang*, which the author understands as *Stile*, 'styles.' The search for this 'melodic schematic contour' is motivated by the author as follows:

> Each of the music styles [i.e. *shengqiang*] ruled by *ban* principles [i.e. *banshi*] only count with a unique melodic skeleton, which is inherent to all the concrete realisations of the style and accordingly works as an essential melodic scaffolding [*Baugerüst*] for the purpose of the whole Style. The intonation differences between the individual styles are based to a large extent on the specific contour [*Gestalt*] of this melodic schema [*Gerüst*]. Contour must be understood here from the viewpoint of a characteristic sequence of notes [*Töneanordnung*], which stands between concrete realisation and the scale [*Leiter*] as total abstraction. (23)

This understanding of the melodic entity in three schematic levels, which Schönfelder calls *Realgestalt*, 'real contour,' *Gerüstgestalt*, 'schematic contour,' and *Leiter*, 'scale,' inevitable resembles the foreground, middleground and background of Schenkerian analysis—although the author does not make an explicit reference to this analytic method—and the analysis implemented in this work clearly shows its influence.

After an introductory section, where general concepts about jingju, state of the art of jingju music research and the goals of the study, Schönfelder's work is divided in three parts. In the first one, the author offers a thorough analysis about the "correlation between text and music." The goal of this first part is to define the melodic form in jingju and from that determine the structural sections upon which the melodic analysis implemented in the following two parts will be based. The author develops a meticulous notation system to point out each element of this structure. In this part of the book, Schönfelder inherits the traditional Chinese musicology understanding of jingju singing melody being structured according to the lyrics structure. Consequently, the author takes the lyrics couplet as the melodic unit, divided into two lines, each of them subdivided in three sections, as Chinese theoretical works commonly agree. The author also takes the *banshi* as analysis units, and studies the metrical characteristics of each of the different structural units for each *banshi*. Once the melodic form has been defined in terms of structure and metre, the following two chapters are devoted exclusively to the melodic analysis of first *erhuang* and then *xipi.* To this aim, the author offers a collection of music scores in staff notation for 35 arias in a supplementary volume, including examples of *erhuang* and *xipi*, for different banshi and male and female role types. As in the Chinese works previously discussed, the analysis follows a *banshi* order, starting by *yuanban*, which is the one analysed in more detail.

Schönfelder's work have two important contributions from traditional Chinese musicology on jingju. First, it applies a Schenkerian-inspired, reductive analysis to the melody. The author argues that

> [t]he identification of a version [i.e., an actual melody from a specific aria] as the original version [*Urfassung*] is impossible. […] The melodic schematic contour itself never occurs in its 'pure' form, nor can it be brought to the common denominator of an absolutely 'pure' form by means of derivatives. It is transparent to the living musical contours [*Gestalten*]. (159, quotation marks from the original)

According to this claim, it can be argued that Schönfelder considers the examples provided in Chinese works as insufficient for explaining a particular *banshi*'s or *shengqiang*'s underlying melodic contour. Therefore, the author carries out a reductive analysis of the first couplet in each example score. The analytical unit is the minimal structural section defined previously, that is, each of the tree subsections of a lyrics line, since they are considered melodic 'units of meaning' (*Sinneinheiten*). Instrumental preludes and interludes are also included. Then, the author analyses how the following couplets in the same aria deviate from the contours of the first couplet. The second important contribution of Schönfelder's work is the attempt to conclude from these analyses a schematic contour for the whole *shengqiang*. However, for this goal the author rejects the attempt of identifying a melodic *Urgestalt*, 'fundamental contour'—the Schenkerian influence is again notorious. The main "obstacles" for accomplishing such a goal are historical. When both *erhuang* and *xipi* arrived to Beijing, they have already experienced a long development process across different xiqu genres that used them, and consequently, in order to reach the fundamental contour, data from this development are needed. At this point, the author argues, the best that can be done is an approximation to the schematic contour, which in terms of Schönfelder's conceptualization, is similar to the Schenkerian middleground (202-3). As a result, the author offers a typification and grouping of the different variants found in the previous analyses for each structural section, or melodic 'unit of meaning.' The melodic schematic contour for each *shengqiang* is a collection of melodic contour groups for each of the six structural units of the melodic couplet.

The methodological contributions of Schönfelder's work for the study of jingju *shengqiang* are remarkable. Rooted in Chinese musicological tradition, it takes on the analytical agreements already established there, mainly in terms of melodic structure and metre, as well as the analytic procedure, centred on *banshi*, and expands the analytical work to the melodic aspect, not present in Chinese works. To do that, the author draws on a well established analytical practice, the Schenkerian one, to model his own purpose and method. Besides, Schönfelder creates a research corpus upon which he builds his analytical work, which is a remarkable qualitative change in approach from the Chinese tradition, where theoretical conclusions can be argued to be supported by personal experience from researches. The shift in the research purpose might have an important influence in this change of approach. The goal of Schönfelder's work is not to assist composition training, but to perform an empirical study of a determined research object. In his analysis though, Schönfelder ignores a fundamental factor that directly influences melodic contour, which are the linguistic tones. Although a common agreement has not been reached among researchers about its details (Xu 2007), its influence has not been questioned and it is considered in most of the Chinese works previously presented (Section 4.2). The results achieved by Schönfelder consist in a series of melodic lines that represent each 'unit of meaning,' providing all the variations required to account for the different melodic lines contained in his analysed collection of scores. Consequently, the results are too sparse and unconnected as to represent the melodic identity of the studied *shengqiang*. On the other, the fact that the variety of versions is related to the specific analsysed database might result in overfitting, thus hindering their capacity for providing extensive representativity. Regardless of these issues, the contributions of this work to jingju music research are undoubtedly outstanding, although it seems to not have exerted the impact it surely deserves.

Contemporary to Schönfelder's work is a publication by Rulan Chao Pian (1972), which presents a different sort of analytical research about jingju music. Much shorter in scope, Pian's work aims at studying precisely the missing element in Schönfelder's volume, namely the influence of linguistic tones in melody. To that goal, Pian analyses the twenty five couplets of a jingju aria. Taking the structural principles agreed in Chinese musicology, the author performs a comparative analysis with the aim of grouping similar contours together and observe their relationship with the linguistic tones of the syllables to which they set music. Her analysis is then applied to the melodic surface, or what Schönfelder would call 'real contour.' Although Pian's research object is not the *shengqiang* (*xipi*) nor the *banshi* (*liushui*) of the aria selected, her conclusions shed light about melodic behaviour in jingju. The melodic structure of the analysed aria (259) presents two basic melodic motives with a series of variations that are used according to the linguistic tones of the syllables, but also its placement within the couplet structure. The amount of data analysed by Pian does not allow to extend these results to the whole *shengqiang*, specially when the selected *banshi*, set to a fast tempo and a 1/4 metre, is characterised by a very syllabic melodic density. However, it offers a new analytic approach to jingju melody, which is proven to provide insightful results on its principles.

More recently, Jonathan Stock has published several analysis on xiqu music, focused not only in jingju (1993, 1999), but other xiqu genres like Shaoxing yueju, from a region in northern Zhejiang province (1999) and 沪剧 huju from Shanghai (2003, 2006), in which Schenkerian inspired—in this case explicitly (1993)—analyses are carried out. Although each of these analyses have different goals, all share a common methodology and an underlying hypothesis to which each work contributes to support. The methodology consists in reductive analysis according to which the selected examples are reduced to their underlying contour with the aim of studying their fundamental melodic motion. An important difference with Schönfelder's analyses is that Stock does not feel constrained by the structural segmentation as established by Chinese traditional theory. In every case, the analysis takes the whole line as basic unit and in further steps the author even aims at deeper, or broader, scopes with the aim of establishing the melodic motion for the whole aria. Indeed, Stock's aim is precisely to challenge the claim from Chinese traditional theory that the melodic unit is the couplet, and in each of his works aims to prove that the arranger of the analysed arias had broader scopes in terms of melody arrangement.

Although sharing a methodological approach, Schönfelder's and Stock's studies differ in purpose, and therefore aim at different results. A worth noticing difference between the two approaches is that, while the former bases his analysis in a corpus of 35 arias, Stock's works are focused on single arias in each case. Of course, the scopes of each author's work is different, and although only single examples are offered to the reader, Stock claims that his observations are based in extensive observation of numerous examples. In fact, the author announced that he once expected "through the analysis of many examples, […] to discover what it meant in musical terms for an aria to be of the *xipi* type as opposed to a variety of *erhuang*" (1999: 192), which is precisely the goal of my own research. While awaiting for Stock's results in this topic—which he then claimed "very far from complete" (1999: 192)—, it can be argued that his work is the first attempt to address jingju music from a new standpoint, although in any case oblivious of Chinese traditional theory.

This sort of melodic analyses have also been carried out by Chinese scholars. Interestingly, two years after the publication of his aforementioned textbook, Zhang$_5$ Zhengzhi, whose analytic interest was explicit in that work, published a study of the common melodic contours between *xipi* and *erhuang*. The results of this work consist in a series of intricate melodic charts organized according the final note and the number of notes, which, due to its length, had to be released in three separate articles (1994a, 1994b, 1994c). These charts are absolutely abstract representations without link to actual realisations, what hinders their explanatory value. However, it is an interesting and novel approach from Chinese musicology to jingju music analysis. More recently, the work of Zhang$_3$ Yunqing *Jingju yinyue fenxi* 京剧音乐分析 (Jingju music analysis, 2011) deviates from the approach of traditional Chinese musicology. As the title announces, the volume is focused on music analysis, and indeed the author includes the analysis of three full plays. Before presenting these analyses, Zhang$_3$ introduces the related knowledge in four chapters: "Survey (概说 *gaishuo*)," "Heterophonic system," "*Banshi*," and "Arias." The different approach from Chinese traditional musicology is already ostensible from this organization. The fourth chapter, "Arias," might be the one that keeps the closest relationship with the Chinese previous tradition, insofar as it studies the structural form of arias. The chapter about *banshi* is novel in the sense that they are presented without a direct connection to *shengqiang* but on their own, similarly to Wichmann's approach. The second chapter about the heterophonic texture of jingju accompaniment is also interesting, since it analyses the melodic interconnection between vocal and instrumental lines in arias. Even though this topic is not new (Liu$_1$ 1992, Zhang$_5$ 1992, Jiang$_2$ 1995), here it gains an unprecedented relevance.

But the most interesting element to my research is the first chapter, "Survey," and specially the section devoted to "nuclear notes" (核心音 *hexin yin*). Although the author does not give a definition of this concept, but directly illustrates it in staff notation, offering two versions for each combination *xipi* and *erhuang*, and *laosheng* and *dan* role types, and one for each *shengqiang*'s instrumental introduction. Simply from a first look, these contours resemble the ones obtained by Schönfelder. Sadly, Zhang$_3$ does not explain the process that let her conclude that these particular contours are the "nuclear notes" of each *shengqiang*, nor she elaborates on their relationship with actual arias. The author does offer the analysis of a couplet from three different arias and even one instrumental prelude, in which a second staff under the original melody displays, in a similar way to Stock's work, what are to be assumed as "nuclear notes" (there is no explicit indication about it though). This concept is not exploited in the analyses of the three full plays which conclude the volume, and which are mostly focused on structure and cadential notes, resembling Zhang$_5$

Zhengzhi's approach (1992), and the general interest on form from Chinese traditional musicology. This work indicates that new approaches to jingju music research have been implemented by Chinese scholars in recent years. In one of the undergraduate courses I audited in NACTA, 熊露霞 Xiong Luxia *laoshi*[5] explicitly named "Schenkerian analysis" to the reductions she did of *xipi* and *erhuang* aria examples (see Section 3.2).

2.2. Computational research on jingju music

Before the start of the work here presented, computational approaches to the research of jingju music were minimal, and in general, their aim was not the study of this music's characteristics, but taking it as a new test case for previously established tasks. Even though these approaches to music research are quite young in China, to the best of our knowledge, Yibin Zhang$_2$ and Jie Zhou from Tsinghua University were the first using jingju music for computational research at the beginning of the 2000s. In their work on classification methods, jingju music was just one of the music genres for the algorithm to classify, together with genres from other music traditions, like "piano," "symphony," "popular song," and either "Chinese comic dialogues" (2003) or "speech" (2004). Few years later, in collaboration with Xia Wang, they proposed a classification method for different xiqu genres, including "Kunqu opera, Pingju opera, Henan opera, Shaoxing opera, Hebei opera, Huangmei opera and Jin opera" (2008: 2476).[6] In these works, the authors follow a similar methodology, consist-

[5] During my research stay at NACTA (Section 3.2) I studied with several members of the faculty. In the Chinese higher educational system, specially in art related fields, the tenure career is different from English speaking countries, and holding a position as faculty in a higher education institution does not imply the same academic background. In order not to mislead the reader, but also not to fail in providing these instructors the deserved courtesy treatment, henceforth I will use the romanisation of the title laoshi 老师, usually translated as 'teacher,' but with a more broader use in contemporary China, as a respectful title to a person holding a specialization position, especially in the realm of education. It is used after the full name or the family name.

[6] The authors do not give more details about these genres. Kunju, 评剧 pingju, and huangmei, commonly known as 黄梅戏 huangmeixi, don't offer any doubt for their identification. "Shaoxing opera," "Henan opera," and "Hebei opera" should respectively refer to Shaoxing yueju, Henan bangzi 河南梆子 and Hebei bangzi 河北梆子, since these are the most popular genres in these regions and the given terms are the most common translations in English. "Jin opera" might probably refer to jinju 晋剧 from Shanxi province.

ing in collecting the research dataset of audio recordings, extracting a series of features from it and applying different classification algorithms, although each publication proposes a new approach to any of these steps. Since the goal is not the study of jingju music, no details are offered about how the extracted features characterise this genre when compared to the others. Besides, the authors gathered an important collection of jingju music recordings for each publication, respectively containing 242 (2003), 147 (2004), and 170 (2008) files, but no detailed description is offered about the source, content or quality of these recordings, and more regrettably, the authors do not give any indication about how to access them for future research.

Another work by two researchers from East China Normal University, Ziqiang Zhang[6] and Xinwei Wang (2011) uses jingju music recordings for the study of automatic segmentation. In this work, the authors gathered a collection of 30 recordings, that were annotated by “four experts who are experienced about Peking Opera” (240) as ground truth, extracted a series a timbral features and implemented a Hidden Markov Models (HMM) method to automatically segment the recordings based in that timbral information. The creation of the dataset annotated by experts is an important contribution for the computational research of jingju music. However, the authors do not offer a description of either the dataset nor the annotations. In fact, they don’t specify which criteria were followed by the experts for the segmentation, beyond the musically vague statement that a “segment in the structure is a region with some internal consistency which implies that it has temporal boundaries” (237), nor whether they all annotated the same recordings and if so, if there was an agreement between them, since the authors acknowledge that “different divisions can be considered ‘correct’” (240).

More recently, researchers affiliated to Tsinghua University, Rashedul Islam, Mingxing Xu, and Yuchao Fan (2015) have created a database of recordings for computational research of xiqu music. It covers fourteen xiqu genres,[7] including twenty samples for each genre. The authors only

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[7] The authors provide the names of each genre with Chinese characters, so they cannot be mistaken. Although the paper uses different English translations, the genres included in the database are 川剧 chuanju , 二人转 errenzhuan, Hebei bangzi, 花鼓戏 huaguxi, 淮剧 huaiju, huangmeixi, jinju, jingju, kunju, pingju, 秦腔 qinqiang, 豫剧 yuju, Shaoxing

mention that they were downloaded from several websites, but don’t discuss their quality. Interestingly, “three volunteers” (40) annotated the section boundaries of each recording, and labelled the sections as “music,” meaning instrumental sections, “song,” including the vocal part, and “speech.” The authors offer some statistics about the database from these annotations. Regrettably, the article does not include any indication for accessing the database.

Besides these studies by Chinese scholars, the specialist in vocal acoustics Johan Sundberg has collaborated with researches from different Chinese institutions for the study of different qualities of vocal emission in kunju singing, like timbre (Dong et al. 2014a), and loudness and pitch (Dong et al. 2014b), in kunju declamation (Han and Sundberg 2017) and jingju singing (Sundberg et al. 2012). In this later work, the authors created their own recordings of four *laosheng* actors and three *jing* actors, including speech, declamation and singing. From this recordings they studied features of loudness, tuning, vibrato and timbre. Despite the limited size of the data, the authors make some interesting observations about the differences of male singing in jingju and opera. Again, no indications are provided about the possibility of accessing these recordings for further research.

Besides these early works, most of the computational research on jingju music has been carried out during the timespan of the research here presented, and concentrated in two research groups, the Centre for Digital Music (C4DM) from Queen Mary University of London, and the MTG, in the framework of the CompMusic project (see Section 1.3). One of the first works published by a researcher from C4DM is the paper leaded by Dawn Black (Black et al. 2014), who has also participated in other works related to xiqu from this group. In this paper, the authors develop a system for the automatic analysis of emotions in several xiqu genres. A great contribution of this work is the creation of the first accessible collection of jingju recordings for computational research, included in the Singing Voice Audio Dataset (SVAD).[8] This collection includes 74 original *a cappella* recordings made by the authors of professional, semi-professional

yueju and Cantonese yueju.

[8] http://isophonics.net/SingingVoiceDataset

and amateur singers, both male and female. It contains 45 samples of jingju, 6 samples of kunju, 2 samples of yuju, 7 samples of Chinese traditional songs and 11 samples of opera. For many recordings, the instrumental accompaniment track is also available. The collection is accompanied by a spreadsheet containing metadata of the recordings, such as the name of the singer, his or her nationality, institutional affiliation and singing proficiency, the name of the song and the genre it belongs. Furthermore, they are annotated with the emotional content associated to them. This collection is of great value, and the jingju recordings have been recently added to the new larger Jingju *a Cappella* Recordings Dataset, created at the MTG (see section 5.4).

The researcher from C4DM who has taken the most active profile in jingju music research has been Mi Tian. In her doctoral research (2016c), Tian has addressed the issue of cultural specificity in MIR. Having realised that most technologies developed in this discipline have taken only Western music genres as the only source of data, and consequently their functionality might be biased to the musical characteristics for these genres, her work aims at finding techniques that overcome this limitation and are able to produce satisfactory results also for other music repertoires. To achieve this goal, during her research Tian worked with existing corpora of Western music genres, and as an alternative music tradition, she decided to focus on jingju, for whose research she created new databases. Her work is focused in two standard tasks in MIR, namely audio onset detection and music structural segmentation. For the first task, besides using two existing datasets of Western instruments and music samples with onset annotations, Tian created, in collaboration with researchers from MTG, a large dataset of the five standard instruments that form the percussion ensemble in jingju, namely the 单皮鼓 danpigu drum, the 板 ban clappers, the 铙钹 naobo cymbals, the 小锣 xiaoluo small gong, and the 大锣 daluo big gong. Due to their timbral similarities, their analogous function in the structure of percussion patterns (锣鼓经 *luogu jing*), and the fact that they are played by the same musician, recordings of danpigu and ban were labelled together with the term by which they are conjointly named in jingju circles, namely 板鼓 bangu.[9]

[9] Personal communication from the authors.

The database contain more than three thousand samples of these four instrument classes, bangu, naobo, xiaoluo and daluo. Their onsets were annotated manually "by three participants without any Beijing Opera background" (2014a: 2160), and the ground truth was obtained as an average of these three annotations. A subset of this collection containing 236 recordings is openly published online.[10] These recordings were used by Tian et al. to develop an algorithm for the automatic detection of each instrument's onset (2014a), as well as, in combination with other datasets of Western instruments, for the improvement of onset detection results by fusing different state of the art algorithms and searching the best parametrization settings for optimal results (2014b).

In order to address the task of music structural segmentation, Tian and Sandler created a new dataset containing "30 excerpts from commercial CDs […] released in the recent decade with recordings of classical repertoires performed by the most renowned musicians" (2016b: 562). Although no detailed description of the contents of the collection are provided, the criteria for selecting these excerpts were "repertoire coverage, structural diversity and audio quality" (562). The recordings are annotated in terms of structural segmentation by three listeners, whose annotations were then verified by two reviewers knowledgeable about jingju. For these annotations, Tian and Sandler specifically rejected the functional principle, according to which a recording is segmented in terms of the structural units that are pertinent to their music genre, and consequently labelled with the function each segment has in that genre. The segmentation principle selected for the annotation of these recordings is "low-level music similarity," according to which a segment is defined by a "music idea" in terms of timbral characteristics (2016a: 23:5), a principle similar to the one followed by Zhang$_6$ and Wang for their collection (2011). The goal of doing such annotations is that

> functional [...] annotations can be highly genre dependent, meaning that segmentation results of one dataset are not necessarily comparable to those of another, whereas low-level music similarity is a phenomenon that can be observed across different genres [...]. Assessing the structure on a music similarity level provides a fair comparison between genres and datasets. (2016a: 23:5)

[10] http://compmusic.upf.edu/bo-perc-dataset

For Tian and Sandler this is an important factor, since their aim is to develop technologies for cross-cultural applications. The annotation files and the metadata of the associated annotated are publicly available,[11] but not the recordings, probably due to copyright issues. However, from these available metadata I could identify some recordings in the Jingju Music Corpus (JMC, Chapter 5) gathered in the MTG, and therefore study the annotations contained in Tian and Sandler's dataset. These consist in the time-stamps that mark the segment boundaries, and no segment is labelled. After listening to the annotated segments in three recordings from the same release,[12] I come to the following conclusions. As Tian and Sandler themselves acknowledge, timbre perception is a very subjective phenomenon (2016c: 20), as it is the very task of music structure segmentation (2016a: 23:1). Consequently, and although annotators were asked to be consistent (Tian 2016c: 194), the annotations result to me in some points controversial. For example, both samples "7longfengchengxiang" and "9tiannusanhua01" start with a percussion pattern, respectively, 慢长锤 *man changchui* and 导板头 *daobantou*. However, although both are performed by the same ensemble of percussion instruments, what might convey a timbrically homogeneous sonic experience, in the first case the pattern is divided in five segments (the first xiaoluo solo stroke, then three segments whose beginning coincide with the daluo stroke, and the rest), whilst the *daobantou* is annotated in a single segment. Two observations should be done though. On the one hand, it must be noticed that *man changchui* is much longer than *daobantou*, the former lasting 26.4 seconds and the latter 10.6 seconds. On the other hand, from an overall look to the segments, as displayed in Sonic Visualiser (Cannam et al. 2010), the software used for annotating the recordings, it can be observed a certain regularity in the length of the segments.[13] This might indicate a

[11] http://isophonics.net/content/jingju-structural-segmentation-dataset

[12] They are the tracks 6–8 from *Jingju zhi xing: Diao Li zhuanji* 京剧之星：刁丽专辑 (Jingju stars: Diao Li's album, https://musicbrainz.org/release/83ddf900-5c79-4dd9-b534-f2bcc871d566), respectively corresponding to the annotation files 9tiannusanhua01.csv, 9tiannusanhua02.csv and 7longfengchengxiang.csv.

[13] The mean of the segment durations is 9.72 seconds, with a standard deviation of 5.27. As for the rest of annotation files, the same data are as follows:

1bawangbieji.csv	9.87	5.06
1yuzhoufeng01.csv	11.8	6.18

cognitive coercion for structuring unknown music into segments of a certain duration related to the capacity of memory. Of course, this is just a preliminary observation needed of proper research and validation. Besides, my knowledge of the fact that those sounds correspond to specific patterns might have conditioned my perceptive experience, as with the case of the instrumental preludes that follow the introductory percussion patterns. It is interesting to observe, related to the two previous remarks, that when the melodic lines, as established by jingju music theory, that is, those corresponding to singing a lyrics line, are considered, they appear

1yuzhoufeng02.csv	10.5	6.5
2kongchengji.csv	10.23	5.0
2lilingbei.csv	12.79	6.05
2wenzhaoguan.csv	12.04	6.13
2xucepaocheng.csv	9.93	6.01
3dayushajia.csv	9.11	3.93
3nuqijie.csv	9.11	3.95
4qingguance.csv	14.28	7.0
4yaoqi.csv	8.18	3.46
5suolinnang.csv	9.91	4.69
6liuyuexue.csv	8.73	4.13
6zhuofangcao01.csv	7.93	3.27
6zhuofangcao02.csv	7.33	3.03
7jinyunu01.csv	7.86	4.0
7jinyunu02.csv	7.43	3.28
7jinyunu03.csv	8.32	3.44
7longfengchengxiang.csv	10.1	4.11
7sangyuanjizi.csv	11.16	5.97
8zuozhaidaoma01.csv	8.78	3.02
8zuozhaidaoma02.csv	7.41	2.85
9shangtiantai01.csv	7.55	2.8
9shangtiantai02.csv	7.0	2.87
9shangtiantai03.csv	8.48	3.7
9tiannusanhua01.csv	11.19	3.72
9tiannusanhua02.csv	8.87	4.39
10hongniang01.csv	10.25	5.41
10hongniang02.csv	8.69	4.8
10hongniang03.csv	11.68	8.44

divided into several segments in the annotations, like the first line of 7longfengchengxiang.csv, sung in the *banshi* called 慢板 *manban*, which lasts 71 seconds and is divided into six segments. Interestingly, the first two of these segments correspond to the first two sections of the line, including the instrumental interludes—which surely are timbrically different—, the third segment contains the first syllable of the third line section and an instrumental interlude, the fourth segment includes the last two syllables of the line, and the melismatic extension (拖腔 *tuoqiang*) of the last syllable starts at the end of the fourth segment and it lasts during the following two segments.[14] In the case of 9tiannusanhua02.csv, the first six lines and the first two sections of the seventh line of the aria are sung in the *banshi* called 流水 *liushui*, which requires a very syllabic style of singing, and in which a line is sung one after another without other break than a short breath. This creates an arguably homogeneous timbral space for nearly 43 seconds, but in the annotations this space is segmented according to the sung lines. Perhaps the knowledge about jingju of the reviewers might have influenced the annotations. If this knowledge might guide music perception, the lack of it might render the task too vague, since the only criterion is then such an abstract and subjective idea as “music similarity,” and this circumstance might undermine the goal of “fair comparison between genres” aimed by the authors. As a conclusion, from a jingju music research point of view, as previously described these annotations do not always reflect jingju structure, so they do not offer a sound reference for the study of this aspect of jingju music. However, it has to be noticed that this is not the goal for which the annotations were intended. The dataset previously described is joined to existing ones, containing several genres of Western music, in order to obtain a research object that overcomes the Western bias of previous studies. With this joint collection of datasets, Tian and Sandler analyse how the combination of different extracted features, different structure models, and different existing segmentation algorithms affects the obtained results (2016a), concluding that different configurations of these three elements are able to better capture structural characteristics of different music genres. The authors also propose methods to improve the obtained results, like adding a har-

[14] The duration in seconds of the six segments respectively is: 11.23, 14.72, 11.25, 11.48, 11.17, 11.18.

monic-percussive source separation preprocessing step (2016a) or the extraction of gammatone features (2016b). In conclusion, the addition of jingju samples to existing databases can hardly ensure a full cross-cultural performance of the existing algorithms. The fulfilment of such an ambitious task requires a collective effort from the MIR community and Tian's contribution in this direction is worth putting in value.

In his doctoral research, $Yang_1$ Luwei, from the C4DM, studied vibrato and portamento (2016a) with the goal of developing a computational model that allows its automatic detection in audio recordings. For this work, $Yang_1$ et al. used different sources from Chinese traditional music, like 二胡 erhu, whose vibrato characteristics have been compared to those of violin (2013), and jingju singing (2015). In the latter, since his method requires monophonic recordings,[15] $Yang_1$ et al. use jingju recordings from the previously described SVAD to compute pitch histograms and vibrato measurements for *laosheng* and *dan* role types. This study concludes that *laosheng*'s pitch range is wider than *dan*'s, and that the male role type uses a wider and slower vibrato than *dan*. These conclusions, however, should be taken cautiously, since Black's collection include amateur singers, whose control of vibrato might not be proficient. An important contribution of $Yang_1$ et al.'s research is the development of AVA, "an interactive tool for automated detection, analysis, and visualization of vibratos and portamenti" (2016b: 108). This tool, whose beta version is openly available,[16] is an interesting tool for the research of such important performance features of jingju singing as vibrato and portamento.

Some of the researchers from the MTG working in specific MIR tasks within the framework of the CompMusic project have drawn on jingju music data to test or adapt their methods to a different music tradition. The main focus of Ajay Srinivasamurthy's doctoral research is automatic rhythm analysis of Hindustani and Carnatic art music (2016). An interesting approach developed in his work is the use of the mnemonic onomatopoeic syllables used in percussion traditions of Indian art music. In the

[15] In MIR, the terms monophonic and polyphonic do not refer to the musical texture of the music recorded, but whether the audio contains respectively one or multiple sources (i.e. voice or instruments).

[16] https://luweiyang.com/research/ava-project/

case of jingju, the percussion patterns *luogu jing* performed by the percussion section of the instrumental ensemble are also learnt and transmitted via onomatopoeic syllables. Srinivasamurthy used this concept to develop a system for the transcription and recognition of such patterns in jingju recordings, a work in which I collaborated (2014a). To implement this approach, a dataset of labelled recordings of jingju percussion patterns was created. To that aim, we extracted from commercial recordings in our JMC 133 instances of five of the most frequent percussion patterns, namely *daobantou*, *man changchui*, 夺头 *duotou*, 小锣夺头 xiaoluo *duotou*, and 闪锤 *shanchui*.[17] Inspired in the onomatopoeic syllables actually used in the jingju tradition, we developed a simplified repertory of syllables, in which variations and nuances present in actual use are not considered for the sake of clarity and consistency. Using these sequences of syllables as representations of each pattern, Srinivasamurthy et al. draw on the method presented by Tian et al. (2014a), in whose development the first author collaborated, for the detection of the onset of each percussion instrument. These results are input in a system based on a HMM for each of the syllables considered and on a language model with the aim of transcribing the recording into a sequence of syllables. Using the string edit distance measure, each sequence is classified into one of the five patterns. The system, even though does not achieve a high performance in terms of transcription, obtains high results in the classification task.

The doctoral research of Georgi Dzhambazov is focused on tracking lyrics in music audio recording, for which he developed two models for audio and lyrics alignment (2017). An interesting aspect of his approach consists in the consideration of musical knowledge from the specific researched genre in order to improve the results. This “complementary context,” as the author names it, is utilized in two ways, resulting in two different models, one that takes information about the duration of sung syllables, and one that takes information about the musical metre to predict probabilities for the onset of the sung syllables. Regarding the first model, Dzhambazov obtains the duration information from two sources. In the first case, he draws on music scores from the Ottoman Turkish makam tradition, since an important collection of machine readable scores is avail-

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[17] Information about the dataset and how to access it can be obtained from http://compmusic.upf.edu/bopp-dataset

able (Karaosmanoğlu 2012) in the CompMusic project. In a second approach to this model, in which I collaborated, the duration information is obtained from the stylistic features of the researched music genre, in this case, jingju (Dzhambazov et al. 2016). This tradition offers an interesting opportunity for such research since the structure of the melodic line and its relationship with the lyrics is well established in the literature (Section 4.2). From this knowledge, a set of rules was derived, according to which each line is divided in three sections with the possibility of the last syllable of each section to be prolonged. To implement this model, a dataset of fifteen *a cappella* recordings of the *dan* role type was created. The recordings were generated by subtracting the instrumental accompaniment track provided in some releases of our Jingju Audio Recordings Collection (JARC, Section 5.1) from the track that mixes this accompaniment with the singing part (see below). The recordings were manually annotated to the phoneme level by two Chinese native speakers working on jingju music and myself to create the ground truth.[18] The use of the rule-based duration model achieved satisfactory results, with an accuracy of 90%.

Besides these works, in which jingju music was used as an expansion of general research tasks, the work of other researchers from the CompMusic project was exclusively focused on jingju music. Two master theses have resulted from this research. Chen Kainan studied intonation in jingju singing by computing pitch histograms normalized to the first degree of the sung scale. For this research he used a selection of the recordings collection of the JARC. These are polyphonic[19] recordings from commercial CDs that include the instrumental accompaniment. This is an important aspect to consider since, as Chen himself acknowledges, the state of the art algorithm for extraction of the predominant melodic line from polyphonic sources, namely the one developed by Salamon and Gómez (2012), does not produce as satisfactory results as in the music repertories for which it was developed, mostly Western pop and jazz. If this melodic line is not accurate enough, the results derived from it should be taken cautiously. In his thesis, Yile Yang$_2$, who collaborated with Dzhambazov for the lyrics to audio alignment work (Dzhambazov 2016), researched the automatic structural segmentation of jingju aria recordings. Differently

[18] Information to access the dataset is provided here: http://compmusic.upf.edu/node/286

[19] See footnote 15.

from Tian's approach, Yang$_2$ (2016) aimed at functional segmentation, considering three categories of segments, similar to those proposed by Islam et al. (2015), namely singing, instrumental and percussion sections. For his research, Yang$_2$ used a set of 34 recordings from the JARC, and which were manually annotated using the software Praat (Boersma and Weenink 2013) in terms of structure, that is, *banshi*, line, line section, syllable, and percussion patterns.[20] In his approach, Yang$_2$ extracts a series of features from each audio frame and classify them in one of the three segment classes using a support vector machine classifier. Yang$_2$ argues that the selection of features is key to the performance of the method, so he performs a study about which ones are more relevant to the task, concluding that spectral features related to timbre yield better results.

The goal of Rong Gong's ongoing doctoral research is to develop a tool for assisting jingju singing learning. The purpose of this tool is to compare a learner's self recording with a reference recording—e.g., from a teacher—to evaluate their similarity and provide useful feedback.[21] In order to be able to measure the two recordings' similarity, there is a necessary previous step of segmenting them into meaningful units for comparison. Gong's system requires *a cappella* recordings as data source. At the time of starting his research, the only available jingju *a cappella* recordings were the ones included in the previously mentioned SVAD (Black et al. 2014), which does not contain enough data for implementing such research. Consequently, Gong started a process of extending this collection, to which I collaborated. The first approach was to produce *a cappella* recordings from the CD collection in the JARC by separating the singing voice from the accompaniment. Some of the releases in this collection contain tracks with only the instrumental accompaniment, aimed to be used as a karaoke backing for amateur singers. In several of these releases, the tracks containing the singing part were the result of mixing the recorded instrumental accompaniment, that was available in a separate track, with the singing voice without much post-processing either in the instrumental track or the one with singing voice. Consequently, the instrumental track can be subtracted from the one containing singing voice, rendering the latter solo. However, due to post-processing and editing transforma-

[20] Information to access the dataset is available here: http://compmusic.upf.edu/node/349

[21] Personal communication.

tions, not all the results were optimal for research. The result of this process was a collection of 15 *a cappella* recordings of the *dan* role type, which is the one used by Dzhambazov et al. (2016). Besides, we had the opportunity of recording several amateur singers from the UK Chinese Opera Association. Some of these recordings were done by myself during a visit to London in a classroom using a Sony PCM-50 hand recorder, and some of them were done in a recording studio at the UPF when some of these artists were invited to Barcelona to perform. As a result, the previous collection was expanded with 17 recordings including *laosheng*, *dan*, *jing* and *xiaosheng* role types. The sum of all these recordings, including those from SVAD, the ones obtained by subtracting instrumental tracks, and the recordings made in London and at the UPF, form the first part of the Jingju *a Cappella* Recordings Collection (JaCRC-1, Section 5.4).[22] For this collection, Gong did some corrections to the phoneme annotations used by Dzhambazov et al. (2016), and expanded them to the whole collection, which is now completely annotated at the line, syllable and phoneme levels. These annotations are included also in the JaCRC-2.

Having gathered this corpus, Gong started the building of his system by developing a method for automatic segmentation of the recordings into meaningful units for comparison. The first approach aims at segmenting the melodic contour into "steady, transitory and vibrato" regions using a melodic transcription algorithm enhanced by the incorporation of genre specific knowledge, namely, bigram note transition probabilities (Gong et al. 2016). For this work, Gong et al. manually annotated these regions in all the recordings from the JaCRC-1, and these annotations are openly available.[23] After field work carried out during a research stay in NACTA that we shared (Section 3.2), Gong realised that in jingju training the correct delivery of each syllable is of utmost importance, and considered that a sung syllable is a more meaningful unit for similarity measurement. Similarly to Dzhambazov's approach, Gong's method uses syllabic duration from music scores to enhance the automatic segmentation algorithm. In a first implementation of this method (Gong et al. 2017a), the authors manually extracted the duration information from printed scores included

[22] https://doi.org/10.5281/zenodo.780559

[23] https://doi.org/10.5281/zenodo.832735

in the JMC and on-line editions[24] for all the recordings included in JaCRC-1. This information and the syllable level annotations are openly accessible.[25] The duration information is then incorporated into a Viterbi decoding algorithm together with an Onset Detection Function (ODF) extracted from the recordings to enhance the segmentation. In a more recent implementation of this method, developed in collaboration with Jordi Pons (Pons et al. 2017b), the authors draw on Convolutional Neural Networks (CNN) to improve the ODT, since a high accuracy for segment boundaries is needed. In parallel to this research, Gong is also developing a method for the automatically matching of an audio recording with a music score. Since in the final application the user won't necessarily input the editorial information of the recorded aria, this matching should be done through the melodic content of the recording. However, due to the fact that jingju melodic material is limited and reused in many different arias, using only melodic information could produce false matching. Consequently, Gong considers phonetic information from the recording to match the score by also using the lyrics. To this goal, he has benefited from a CNN approach to propose an enhanced acoustic model (Pons et al. 2017a). Compared with other acoustic models, like deep neural networks and Gaussian mixture models, CNN yields the best results, in combination with a hidden semi-Markov model for duration. In this work, Gong et al. (2017b) used a collection of machine readable scores created by myself from printed sources (Section 5.2).

During a second research stay in NACTA, Gong has recorded five professional and four amateur jingju actors and actresses in two studios, obtaining 120 new *a cappella* recordings, including *laosheng*, performed by both male and female singers, *dan*, also performed by both male and female singers, and female *jing* role types. Interestingly, Gong was also able to record professional jinghu players that accompanied two of the professional singers, so that for those arias both the singing and the accompaniment parts are available in different tracks. This collection, which has been recently published (Gong et al. 2017c), forms the second part of the Jingju *a Cappella* Recordings Collection (JaCRC-2), which is also openly

[24] Personal communication

[25] http://doi.org/10.5281/zenodo.345490

available.[26] All the recordings have been annotated with the starting and ending time of each line, resulting in 1265 melodic lines, which has been labelled in terms of role type, *shengqiang*, *banshi* and the sung lyrics. All these annotations are included in JaCRC-2. As a result and summing both its parts, JaCRC is the largest dataset of annotated jingju *a cappella* recordings fully available for research, and it is a part of the JMC (for a more detailed description, see Section 5.4).

The vast majority of the works presented in this section take jingju music as research data source, but not as a research object, being this a different MIR task in each case, such as structural segmentation, onset detection, automatic detection and classification of different elements (vibrato, patterns, instrument, syllable), automatic segmentation, lyrics to audio alignment, etc. That is to say, the goal of most of this research is not deepening our knowledge about jingju music, but to improve technologies with a specific application to this music genre. In some cases, musicological questions have been raised. In Islam et al.'s work (2016) the different average length of each of the considered segment classes, singing, instrumental and speech, is compared for the fourteen xiqu genres included in the collection, in order to comparatively characterise them. However, the lack of information about the content of the collection, the sources and the criteria for selecting the recordings and segmenting them suggests that this results have to be taken cautiously. The conclusions by Chen (2013) about jingju singing intonation should also be carefully taken, due to the lack of accuracy in the extraction of the predominant melodic line from the polyphonic recordings. More interestingly, Yang_1 has observed some pitch range and vibrato features to characterise *laosheng* and *dan* role types. Of course, all these researchers work in the field of MIR, and such contributions to musicological research are not their main goal. Unquestionably, the main contribution of all this research consists in providing musicologists with data and tools with which perform their research.

2.3. Conclusions

The musicological study of the jingju musical system in the Chinese academia has developed a standard methodology, which has *banshi* as the

[26] https://zenodo.org/record/844909

essential description unit, grouped by *shengqiang* and specified for *laosheng* and *dan* role types. Customarily, the order of explanation starts from *erhuang*, then *xipi* and then the secondary *shengqiang*, and for each of them the first described *banshi* is *yuanban* for *laosheng*, since the rest are considered as developed from it. For the explanation of each *banshi*, the lyrics couplet is taking as basic unit, since it is assumed that it establishes the melodic unit, which is consequently conceived as formed by two lines, each of them divided into three sections. Regarding the description of the element that is the focus of this thesis, namely *shengqiang*, most descriptions focus on cadential notes, the metrical position of the lyrics and their expressive function. Chinese authors generally do not present analytical studies of the concepts explained, but mostly offer a textual explanation illustrated with examples from real arias. This circumstance might be motivated by the fact that most of Chinese literature on the topic is conceived with an eminently practical application as textbook for jingju music composition. Analytical studies of jingju music are found in English literature, taking comparative and reductive analysis as the main methodologies. Regarding the first approach, which is the one proposed for this thesis, the data analysed consist in one aria by Pian and 35 by Schönfelder.

Source	Rec.	Ann.	Research task	Accessible
$Zhang_2$ and Zhou (2003)	242	No	Classification	No
$Zhang_2$ and Zhou (2004)	147	No	Classification	No
$Zhang_2$ et al. (2008)	170	No	Classification	No
$Zhang_6$ and Wang (2011)	30	Yes	Structural segmentation	No
Sundberg et al. (2012)	7	No	Acoustic features	No
Black et al. (2014)	45	Yes	Emotion identification	Yes
Islam et al. (2015)	20	Yes	Genre recognition	No
Tian and Sandler (2016b)	30	Yes	Structural segmentation	Only annotations

Table 1. Databases for jingju music singing research
in the state of the art literature (excluding the JMC). Rec. stands for number recordings, Ann. stands for annotations. Accessibility assessed according to its statement in the related publication.

Regarding the use of computational approaches to jingju music, they are undertaken by researchers who work within disciplines close related to computer sciences, especially from MIR. In most of these works, the use of jingju music was motivated by the aim of expanding the research data to other music traditions and therefore overcoming the common cultural bias of standard databases in these disciplines. However, the undertaken research tasks are the commonly established in the respective fields and, with some exceptions, no contributions were aimed for improvement of jingju music understanding. For many of these tasks, research databases were built. Table 1 summarizes the existing databases which contain data for the research of jingju singing (excluding those built for the study of instrumental aspects of jingju music).

The contributions expected to be obtained in this thesis are defined from the overview presented in this chapter. The main one, that is, deepening the state of the art understanding of jingju two main *shengqiang*, is rooted in the scholarly tradition established by Chinese musicology, to which the work here presented aims at contributing with knowledge empirically obtained from the comparative analysis of data (Chapter 7). Therefore, before engaging with the analytical work, a detailed description of the jingju musical system as explained by this tradition is presented (Chapter 4), so that the expected contributions are better understood in relationship with it. Compared with previous analytical approaches to this issue, the present research aims at achieving more solid conclusions by, on the one hand, expanding the analysis corpus, and on the other hand, drawing on computational approaches (Chapter 3). Regarding the former, the work here presented aims at contributing to the creation of the largest, openly accessible corpus for jingju music research (Chapter 5). Regarding the latter, statistical and quantitative information (Annex 2) is computationally extracted using a specifically to this aim written code (Sections 6.1 and 7.2).

Chapter 3 Methodology

This is a thesis essentially of music analysis. The selection of the appropriate analytical method is motivated by both the characteristics of the music to be analysed and the research question about that music that is aimed to be solved. Considering these two key aspects, the core method utilized in the research here presented is comparative analysis. However, this method is influenced by two important factors, namely my own academic background and the research context within which the thesis has been developed. Any music analysis requires a cultural understanding of the music to be analysed, so that the proposed question and the implemented method are appropriate. Since the music analysed in this thesis is alien to my own cultural background, I draw on the fieldwork method I learned during my training in ethnomusicology. The goal is to obtain the required information about the cultural background of the analysed music in order to inform the research objectives and the analytical method. On the other hand, this research was carried out in the context of the CompMusic project, whose core discipline is music information retrieval. Benefiting from this context, I added computational tools to the central comparative analysis method, with the aim of supporting and expanding the obtained results with quantitative and statistical information. In the following sections I will describe in detail each of these three components, namely comparative analysis, fieldwork and computational tools. I will conclude with a discussion about the consequences of such methodology for its ascription to an academic discipline.

3.1. Comparative analysis

The methodology developed for this thesis was originally inspired in one of the fundamental works for the study of Chinese *xiqu*, namely Bell Yung's *Cantonese Opera* (1989). This volume's subtitle is *Performance as creative process*, and indeed Yung offers a top-down analysis of all the factors that explain how music is created in this genre, from a historical presentation of the formation of Cantonese yueju up to the 1970s—when the author realized his fieldwork in Hong Kong—to the social context within which the genre is staged, to whom and by whom it is performed, the script and lyrics, and the musical system. As a result of this analysis, Yung observes a series of rules that establish the fixed part of the performance as well as others which offer the performer guidance for improvising and creating while performing. His study of yueju's musical system is especially interesting for my research, since this genre is historically related to jingju. One of the central elements of this system is 梆王 *bongwong*, which he translates as "aria types", and is directly related to jingju's concept of *banshi* explained in section 4.5. Yung argues that "[a]ll *bongwong* songs share several basic structural features which bind them with a stylistic coherency" (67). However, the author continues arguing that

> [t]wo versions of the same aria type, because they are sung to different sets of text, almost always differ in melodic contour. […] Some structural features in these versions must be invariable to allow a listener to recognize that a song passage is one aria type and not another. (68)

In order to analyse "the structural features that appear to be invariable, or nearly invariable," (69) Yung provides a figure (numbered 7.2, p. 69) with the transcription of the melody for 9 couplets of the *bongwong* called 七字清 *chatjiching*. However, in the subsequent analysis of the "invariable, or nearly invariable" features, the author discusses the lyrics structure, the metrical position of the lyrics characters, the cadential notes and the instrumental accompaniment (69–71). The only feature related to the pitch component of melody analysed by Yung is the so-called 線 *sin*, which the author defines as "a tonal feature or a set of tonal rules which, on the simplest level, may be understood as somewhat equivalent to a 'scale.' But on the other levels, it may be equated with the concepts of 'key' and 'mode.'" (70) In order to analyse in detail this element, which is one of the features that convey unity to the different *bongwong* versions, Yung devotes to this topic a whole chapter, in which he studies the three aspects of *sin*, namely scale, key and mode. In order to do that, the author analyses in detail three different *sin*. However, since *sin* is expressed through *bongwong*, the study of each of them is performed by the comparison of the melodic contour of several lyrics couplets—seventeen for two of them, and sixteen for the third—from arias that share the same *bongwong* and other structural elements, and differ only in *sin* (figures 10.4 to 10.6, pp. 112–117). One common characteristic of all these figures is that "[i]n order to facilitate comparison, the versions of each line of the couplet in each *sin* are aligned vertically so that the metrical, rhythmic, and phrasal patterns are clear at a glance" (111).

This type of comparative analysis of aligned melodic units in order to study their commonalities has been widely used both in historical musicology and ethnomusicology. A particular field of research from the first discipline in which this approach has proven to be especially fruitful is European plainchant research, with as early works as those by Egon Wellesz in 1920, Paolo Ferretti in 1938 and Helmut Hucke in 1953 (all of them referenced by Powers 1980: 12–15), in which the authors build charts of aligned related melodies in order to study their underlying melodic types. An influential work in this matter is Leo Treitler's study of the "formulaic system" developed for the oral transmission and creation of plainchant. In his publications (1974, 1985), Treitler frequently draws on charts of aligned melodic phrases from the same piece, different pieces of the same tradition and analogue pieces from different traditions in order to both synchronic and diachronically observe the function of melodic formulae.

Within the discipline of ethnomusicology,[1] this approach has been mostly used in relation with the analysis of tune families, and is already found in 1954 in Samuel P. Bayard's study of English folk-song families (Powers 1980: 12). In his work on *Venda Children's song*, John Blacking (1995, originally published in 1967) aims at understanding which musical

[1] Comparative studies in ethnomusicology generally refer to the search of commonalities across different music traditions. Here, I refer to the specific method of comparative analysis of melodic units, usually arranged for that goal in aligned charts. Nettl (2005: 60–73) offers an overview of the different methodologies developed by ethnomusicologists for the comparative studies.

elements relate groups of songs into a single repertoire, as classified by the Venda themselves. To that aim, Blacking also draws on the comparison of transcribed songs, by aligning them vertically in charts, so that melodic units that share the same melodic material appear in the same column. Within the studies of Chinese traditional songs, this method has also been used by Antoinet Schimmelpenninck (1997) in her research on the folk song genre known as 山歌 *shan'ge* in the Southern province of Jiangsu. The author argues that one of the most relevant characteristic of this repertoire is its "monothematism" (224), by which she means that each village owns a unique tune, and each singer in the village perform his own variant. In order to support her argument, Schimmelpenninck aligns 11 songs by different singers from the same village in order to perform a comparative analysis of their common features and study their melodic variability (232–249). Later on, different groups of songs from different villages are also aligned and compared in order to identify their own characteristics (260–276).

All the studies previously mentioned share the analytical procedure of selecting representative melodic units and align them in a setting that facilitates its visual comparison. However, the analysis method and the obtained results are directly dependent on the research question posed by the analyst. In Leo Treitler's work, his aim is to study the formulaic structure of plainchant, and therefore the output of his comparative analysis is the identification of such formulae, and how they interrelate pieces to form melodic types. In John Blacking's work, the result is an underlying model that is shared by the analysed songs so that they can be classified into a single repertory. In the case of Bell Yung and Antoinet Schimmelpenninck, one of the results is a series of textually described common characteristics. Bell Yung also extracts the common scale, while Schimmelpenninck infers the "skeletal version" or "schematic representation" of the melodic outline shared by the analysed lines.

In spite of this variety of processes and results, Nicholas Cook (1994) argues that the comparative approach to musical analysis presents a methodological advantage compared with other approaches such as the Schenkerian, psychological and formal ones, which is that it allows "to make objective discoveries about the music's structure, rather than to make intuitive judgments about it." (183). Regarding the objectives of this thesis, "discovery" is a key word. The comparative analysis establishes a bottom-up method, which takes the data as a starting point and "discovers" structural or formal characteristics about them. Cook further argues that

> the great advantage of comparative techniques of analysis is that they allow you to approach music very inductively. […] you do not need an *a priori* theory to compare pieces of music; all you need is some means of comparison which is appropriate to the particular music in question. (208)

In the study presented in this thesis, the literature review presented in Chapter 4 results in the establishment of a theoretical framework that guides the analytical procedures. However, the obtained results, even though should coalesce with that theory, are not informed by it, but evaluated against the soundness of the method.

Finally, a representation for the results obtained from the comparative analysis should be defined. As observed in the examples referenced previously, one of the main goals of comparative analysis is to infer underlying structures from the analysed songs, a goal that, at least terminologically, reminds the Schenkerian approach. In his overview on the comparative approach to musical analysis, Cook reviews Mieczyslaw Kolinski's analysis of recurrent movements in Herndon's song, and concludes that "this kind of analysis is certainly analogous to what Blacking was doing, or Schenker for that matter, in that it discovers an underlying structure in relation to which the musical surface can be viewed as a kind of elaboration" (1994: 207–8). By referring to these two studies, Cook is granting certain Schenkerian character to Blacking's comparative work. Jonathan Stock (1993) has specifically advocated for the use of Schenkerian analysis in ethnomusicology, that is, applied to music traditions for which Schenker did not conceived his method for. More accurately, the author proposes a "Schenkerian-inspired" or "reductive" analysis, and effectively applies it to three case studies, including four jingju melodic lines. Stock discusses some of the problems derived from the application of such methods to the music traditions which he analyses, mostly stressing the impossibility of the method for integrating extra-musical concerns of interest for ethnomusicology, or the probable discrepancies between the *Urlinie* obtained from these studies and the rules Schenker devised for it.

The application of Schenkerian analysis to musics from outside the European tonal tradition poses, in my view, two fundamental problems, one of concept and one of application. In the first place, as Cook states, "Schenker saw music as the temporal unfolding, or *prolongation*, of the major triad" (1994: 39, italics from the original). Therefore, this method is not only conceived for a specific music, but it is at the same time the result of a particular conception of that music (in singular) as inherently harmonic. As a consequence, in terms of its application, Schenkerian analysis do not aim at extracting, or inferring, an *Urlinie* from the analysed music, since this *Urlinie* is a theoretical given. The goal of the analysis consists hence in specifying the relationship between the melodic surface or foreground with the underlying, preexisting, or preconceived, background. The result of this analysis, its contribution, is indeed the middleground. Consequently, applying Schenkerian analysis to a single example of a non tonal music would imply the knowledge by the analyst of its preexisting *Urlinie*. Otherwise, the method do not provide tools for getting to the background from the foreground for musics for which the *Urlinie* is unknown.

Considering now the goal of this thesis, the study of the underlying structure of jingju music, I see that the use of Schenkerian analysis as such would impose to this music a tonal or harmonic essence, which it does not have. On the other hand, my analytical goal is to extract, or get as closer as possible to, its underlying structure, which I do not know beforehand, as Schenkerian analysis would imply. As a consequence, I understand that applying Schenkerian analysis to jingju music would impose on either the method or the object elements that are alien to their nature. At this point, the aforementioned statement by Cook that "the great advantage of comparative techniques of analysis is that […] you do not need an *a priori* theory" gains importance. Comparative analysis allows to reach an underlying structure which resembles Schenker's *Urlinie* but which is not known *a priori*. And this is the case of the task undertaken in this thesis.

Having stated the previous issues, I have to acknowledge the influence of Schenker's method in the presentation of the results obtained in this thesis in two aspects. The outcomes from the comparative analysis are presented through melodic schemata, which aims at representing the underlying structure as melodic motion. That is, the goal is to indicate the pitches that propels the melodic line as structural reaching points, as well as those pitches which determine the melodic direction to transition between the previous ones. As a consequence, the schemata present a hierarchy of pitches, those with a structural function within the melodic motion are presented as open noteheads, and those defining melodic trajectories are presented with filled-in noteheads. Since only these two levels are considered and jingju singing is monodic (with an heterophonic accompaniment), there is no need for using stems and beams. Secondly, as in the case of Schenkerian middleground and background analyses, the rhythmic aspect is not represented. Rhythm, and especially metre, are indeed essential components of jingju music. They are however more directly related to the concept of *banshi* than to *shengqiang*, which is the focus of this analysis. This is why, even though no rhythmic information is contained in the resulting melodic schemata, they should be understood as representations of melodic motion, with an inherent temporal dimension. More details about specifics and exceptions of the schemata are provided in section 7.1.

As already mentioned in the case of Schimmelpenninck's analysis, the author develops a "skeletal version" of the compared melodies. This melodic skeleton is a common concept in Chinese traditional music, known as 骨干音 *gugan yin*. Intuitively, this concept could be related with the underlying structure I aim at analysing. However, in Chinese traditional music this concept is well established and differs from this thesis goal. As Jones (1998) argues, the skeletal melody is mostly used in instrumental music and is closely related to music notation. In these genres, only this melodic skeleton is the one learned by a student or written down in notation (111–112). However, in actual performance, it is rendered with genre or instrument specific ornamentation, a process that is known as 加花 *jia hua*, literally 'adding flowers' (126–127). One of the most representative instrumental genres in the use of *jia hua* to skeletal melodies is the so-called 江南丝竹 *jiangnan sizhu*, Southern 'silk and bamboo' ensembles. In his study of this genre, Witzleben (1995) not only analyses the ornamentation process of the common repertoire of skeletal melodies, or 母曲 *muqu*, literally 'mother tunes,' but also compares different versions of these tunes with each other and the melodic relationship of different tunes (70–88). This study shows that the concept of skeleton tune represents a full formed song, close in its concept to the surface, even though it is performed through ornamentation, but from which underlying structures can also be studied. Consequently, it cannot be equivalent to the underlying melodic structure this thesis aims at studying.

3.2. Fieldwork

As explained in the previous section, the comparative approach allows the implementation of the analysis without the need of an *a priori* theoretical formulation of the expected outcome. However, the analytical procedure still needs to be informed by the characteristics of the analysed music, so that the obtained outcome can be plausibly coherent with the principles of the studied music tradition. In Chapter 1 I pointed out that this research is partly motivated by the unsatisfactory explanation of the *shengqiang* concept in the state of the art literature, including Chinese authors, most of them performers and composers of jingju music. However one of the concepts learned from the literature review is that jingju music, at least in traditional settings, is arranged by actors and actresses. Therefore, it seems reasonable to conclude that these performers, even unconsciously, might possess knowledge about *shengqiang*, and that they surely are relevant sources for the study of the proposed topic.

A couple of years before the start of my PhD research, I spent one academic year in 上海音乐学院 *Shanghai yinyue xueyuan*, Shanghai Conservatory of Music, as a visiting student. It was precisely during that stay that I took a course on *xiqu* and storytelling, taught by 黄允箴 Huang Yunzhen *laoshi*, and where I started learning in depth about *xiqu* musical systems. I also joined a *xiqu* singing students association, lead by 张玄 Zhang Xuan *laoshi*. During informal conversations with Zhang *laoshi*, I learned that she graduated from NACTA and that this academy is considered the top institution for *xiqu* training and research, with a special focus on jingju. Therefore, when the need arose for learning from jingju performers, I decided to go to NACTA and learn from their faculty and students.

According to my previous training in ethnomusicology, I assumed the visit to NACTA as fieldwork research, one of the defining methods of ethnomusicology.[2] According to Cooley and Barz's definition, "[f]ieldwork is the observational and experiential portion of the ethnographic process during which the ethnomusicologist engages living individuals as a means toward learning about a given music-cultural practice" (Barz and Cooley 2008: 4). Even though the goal of this thesis is not the creation of a music ethnography about jingju, I understand that fieldwork can benefit my research with the two main contributions that this method offers according to Cooley and Barz's definition. The first objective is learning from the "living individuals" that enliven this music. Using Nettl's definition, my first goal for engaging in fieldwork is to perform "[d]irect inspection at the source" (2005: 148). I did not expect to gain from the performers in NACTA a formally exhaustive theoretical formulation of *shengqiang*. Conversely, my aim was to observe how this element of the jingju musical system is present in and manifest through their every day work (from rehearsal to performance). The second learning means that fieldwork offers, according to Cooley and Barz's definition, is experience, a term which the authors believe "encapsulates the essence of fieldwork" (Barz and Cooley 2008: 4). I relate this experiential learning process with Hood's cannonical concept of bi-musicality (1960). With the aim of being as proficient in the studied music as a bilingual speaker is proficient in the mother and learned languages, Hood argues that the ethnomusicologist must acquire "an ability to hear" that is best achieved by learning to perform through traditional imitative (that is, without notation) methods (1960: 56). Conscious that I will not achieve bi-musicality (if it is achievable at all, Nettl 2005: 56–57) during my research stays in NACTA, I understood that the experiential process of engaging in the learning practices of the academy, even to acquire a basic performance skill in both singing and instrumental techniques, would enhance not only my ability to hear, but also my understanding and appreciation for the genre. In the remainder of this section, I offer a brief report of the experiences and knowledge learned during my fieldwork at NACTA, as well as the information obtained from it of relevance for my thesis research.

I was accepted by NACTA as a visiting researcher from March to June, 2014. The specific settings of my stay were not decided directly by my-

[2] Barz and Cooley (2008) offer an interesting review of recent approaches to fieldwork in ethnomusicology.

self. The Office of International Relations asked me about my expected goals for going to NACTA and they arrange a lessons schedule for me. This weekly schedule included eight hours a week of *laosheng* singing with 李正平 Li Zhengping *laoshi*, four hours a week of jinghu playing with 宋婷婷 Song Tingting *laoshi*, and four hours a week jingju percussion with 范庆涛 Fan Qingtao *laoshi*. The training offered by NACTA to its students is of the top professional level. Students to be accepted in this institution, especially those aiming to study in the Jingju Department, should prove a basic professional level, as the one obtained in the specialized secondary schools for jingju, or other *xiqu* genres, training. Consequently, besides the curriculum of general culture matters, the practical teaching was aimed at perfecting the performance level, usually by improving plays already known by the students. Consequently, NACTA do not offer any beginners course that I could join, and therefore, the schedule tailored to me consisted in one-to-one individual lessons.

The most interesting and fruitful of these lessons were those about *laosheng* singing. Son of the historical *laosheng* actor Li Shengzao 李盛藻 (1912–1990), Li *laoshi* was a retired faculty member of NACTA. After a lifetime of performing and teaching, he was still very energetically and passionately devoted to teaching non professionals, collaborating in different research tasks, and documenting traditional plays which are no longer brought to contemporary stages. After explaining to him my goals, Li *laoshi* designed a plan of theoretical and practical lessons, through which he would respectively explain to me his own personal understanding of jingju art in general and jingju music in particular, and teach me how to sing a series of selected jingju arias, as listed in Table 2. Both of these lesson types were of utmost interest and value for deepening my knowledge of jingju music.

During his lifetime of performing and teaching, Li *laoshi* had developed a personal, well structured understanding of the jingju musical system and its relationship with jingju as a whole. His conceptualization about the rhythmic nature of jingju was especially enlightening, as well as his detailed knowledge of the development and characterization of the different schools for each role type. The singing lessons were even more interesting, at least from an experiential point of view. Li *laoshi* chose to teach me as he always had taught. He will dictate to me the lyrics of the aria to learn (because of my limited knowledge of the language and my continuous interruptions for clarifications, he ended up writing the lyrics on the blackboard) and will start singing, expecting for me to imitate to the best of my capacity his singing. He encouraged me not to use any music notation for learning, but he allowed me to record his lessons. The only concession he granted me for the fact of being not only an outsider to the tradition, but to the language, is that I did not have to repeat his singing line by line from the beginning, but he allowed me some time to first memorize the lyrics and start learning at home from the recorded lessons.

During the singing lessons, the only technology used by Li *laoshi* were two wooden sticks for the 堂鼓 tanggu drum, with which he kept the tempo. I got a pair as a present, in order for me to practice with them, marking the tempo. Every time he demonstrated an aria, he started by singing the instrumental prelude, both percussion patterns and the jinghu line, and after each singing line, he also sang the jinghu line of the instrumental interludes—imitating with the wooden sticks the improvisational patterns done by the drum master. I knew that percussion patterns were learned and transmitted through a set of onomatopoeic syllables, that he used for singing the needed pattern. But I also noted that he sang the jinghu line using a limited repertory of syllables. With the time I came to realize that singing the jinghu line using these syllables is a common practice in jingju circles when actors and actresses practice and there is no instrumental ensemble available. Asked about these syllables, Li *laoshi* explained that they tried to convey the feeling, although not in a strict way, of certain jinghu playing techniques. For an actor or actress it is fundamental to know in detail the percussion pattern to be performed at any time, since stage movements might be associated to them, as well as the melody of the instrumental accompaniment, also for the sake of possible stage movements, but especially because they have to be very clear about the melodic cues for singing and, as Li *laoshi* put it, give back the melodic line to the jinghu. It's importance is such that I was encouraged to also learn this instrumental melody using the mentioned syllables.

During the singing lesson, once I had had time to prepare the singing at home, Li *laoshi* requested me to start singing—I chose the pitch range—from the instrumental interlude. Any time a problem arose, he interrupted

research stay	aria	role type	shengqiang	banshi	Li *laoshi*	Song *laoshi*	Fan *laoshi*	Zhuang Xuan
1 & 2	"为国家哪何曾半日闲空" ——《洪羊洞》（杨延昭） "Wei guojia na he ceng ban ri xian kong," *Hong yang dong* (Yang Yanzhao) "Have I ever rested from my duties to the country even half day?" *The cave of Hongyang* (Yang Yanzhao)	*laosheng*	*erhuang*	*yuanban*	✓	✓	✓	✓
1 & 2	"杨延辉坐宫院自思自叹" ——《坐宫》（杨延辉） "Yang Yanhui zuo gongyuan zi si zi tan," *Zuo gong* (Yang Yanhui) "I, Yang Yanhui, sitting in the palace hall, sigh thinking of myself," *Sitting at the Palace* (Yang Yanhui)	*laosheng*	*xipi*	*manban, erliu, yaoban*	✓			
1	"金乌坠玉兔升黄昏时候" ——《碰碑》（杨继业） "Jinwu zhui yutu sheng huanghun shihou," *Peng bei* (Yang Jiye) "The Golden Crow falls, the Jade Hare rises, the dusk," *Death at the stele* (Yang JIye)	*laosheng*	*erhuang*	*daoban, huilong, manban*	✓			
1	"贤妹暂坐雅致厅" ——《牧护关》（高旺） "Xian mei zan zuo yazhi ting," *Muhu guan* (Gao Wang) "Virtuous sister, sit with me for a while at the fine hall," *The Muhu crossing* (Gao Wang)	*jing*	*xipi*	*daoban, sanban, yuanban, erliu*	✓			
1 & 2	"老爹爹发恩德将本修上" ——《宇宙锋》（赵女） "Lao diedie fa ende jiang ben xiu shang," *Yuzhou feng* (Zhao nü) "Mi father, generously, will write the petition," *The Universe sword* (lady Zhao)	*dan*	*xipi*	*yuanban*		✓		✓

Table 2. Arias studied during fieldwork.

research stay	aria	role type	*shengqiang*	*banshi*	Li *laoshi*	Song *laoshi*	Fan *laoshi*	Zhuang Xuan
1	“春秋亭外风雨暴”——《锁麟囊》（薛湘灵） “Chunqiu ting fengyu bao,” *Suo lin nang* (Xue Xiangling) “Outside the Spring and Autumn Pavilion a storm bursts,” *The embroidered Unicorn purse* (Xue Xiangling)	*dan*	*xipi*	*erliu, liushui*		✓		
1	“本应当随母亲镐京避难”——《凤还巢》（程雪娥） “Ben ying dang sui muqin Haojing bi nan,” *Feng huan chao* (Cheng Xue’e) “I should have follow mother to take refuge in Haojing,” *The phoenix returns to the nest* (Cheng Xue’e)	*dan*	*xipi*	*yuanban, liushui, sanban*		✓		
2	“两国交锋龙虎斗”——《失街亭》（诸葛亮） “Liang guo jiao feng long hu dou,” *Shi Jieting* (Zhuge Liang) “Two countries battle like dragon and tiger,” *Loss of Jieting* (Zhuge Liang)	*laosheng*	*xipi*	*yuanban, yaoban*	✓			✓
2	“未开言不由人泪流满面”——《坐宫》（杨延辉） “Wei kai yan bu you ren lei liu man mian,” *Zuo gong* (Yang Yanhui) “Even before speaking I can’t contain my tears,” *Sitting at the Palace* (Yang Yanhui)	*laosheng*	*xipi*	*daoban, yuanban, kuaiban, yaoban*	✓			
2	“一轮明月照窗下”——《捉放曹》（陈宫） “Yi lun ming yue zhao chuan xia,” *Zhuo fang Cao* (Chen Gong) “A round moon shines bellow the window,” *Capture and release of Cao* (Chen Gong)	*laosheng*	*erhuang*	*manban, yuanban*	✓			

Table 2. (continuation)

me and addressed the problem by singing the correct version of it. Sometimes he tried to support his demonstrations with some verbal explanation, and sometimes he tried to imitate my wrong singing, in order to letting me perceive the problem. The most frequent of these corrections were related with pronunciation and phonetic articulation, a fact that helped me understand the importance of correct pronunciation for jingju actors and actresses. The second most common type of problems were related to intonation, occasionally regarding a particular pitch, but most commonly in relation with a particular melodic phrase or unit. Finally, a third group of common problems were related with expressivity such as dynamics, melodic articulation and rhythmic nuances. Once I achieved a certain fluidity in singing, he helped me improve also the timbre.

Song Tingting *laoshi*'s jinghu classes were very different in approach. Song *laoshi* is a graduate student from NACTA, young faculty member of the Jingju Department, and an active, celebrated jinghu master. Once I explained to her my goals, she designed a plan of arias for me to learn (Table 2), including arias of both *xipi* and *erhuang*, for *laosheng* and *dan* role types. During the first lesson, Song *laoshi* gave the basic indications about how to hold the instrument and the basic playing technique. My previous experience with erhu playing helped me to quickly understand the concepts, but was a handicap when needed to learn the quite different bowing and fingering techniques. In that very first session, I already got the first score to start playing. The teaching method consisted in providing me with a score, which Song *laoshi* revised and, if needed, changed some notes according to her personal playing habits or to my absolute beginner level. Once I got the score, I should first hum it, and back home learn to sing it, including the instrumental prelude and interludes using the onomatopoeic syllables as with Li *laoshi*, although in this case in a more simple manner, with the goal of having in mind at every time the singing line. Then, right after I got the score and hummed it, she asked me to start playing from the score. The goal for each of the studied arias was to perform the score as faithfully as possible in terms of correct tuning and rhythm. During my playing, she interrupted for correcting problems of tuning and rhythm, and if needed, for improving any technical issue. Occasionally she demonstrated certain passages playing her own instrument. Song *laoshi* did not allow me to record the lessons and her playing, just arguing that there was no need for that, and that many recordings are available online. The most problematic passages were those of the jingju characteristic rhythmic flexibility, especially those in free meter. Song *laoshi* method for helping achieve the expected result was to draw on the singing line that I should have memorize—a method that turned out to be too elusive for me.

Fan Qingtao *laoshi*, a young faculty member of the jingju department and active drum master, was the least enthusiastic about my intentions in NACTA. During the lessons with Fan *laoshi*, I realized the extreme technical difficulty for the performance of the danpigu drum and the ban clappers, which were my learning targets. I could hear since early hours in the morning the percussion students ceaselessly practicing drum rolling, maintaining a high and constant volume, well-balanced pitch between the two sticks, and a steady and astonishingly high speed. This was the so-called 基本功 *jiben gong*, basic skill, on top of which everything is built. In the case of the ban clappers, even though not as extreme as with the danpigu drum, the required basic skill is very similar. I came to conclude during my lessons with Fan *laoshi* that he was of the opinion that without this basic skill no serious teaching was worth attempting for the time span I planned to spend in NACTA. During the first lessons, Fan *laoshi* aimed at training me in the explained basic skill, for both danpigu and ban. He even granted me free access to his classroom at any time for practice. However, considering the expected slow pace of my progress, for whose improvement only hours and hours of practice is the solution, Fan *laoshi* changed his approach, and devoted the lesson time to answering my questions.

Besides specific questions about the construction of the instruments and about the professional life of a jingju percussionist, I used this opportunity to learn his version of the most used percussion patterns—which I wrote down using the common onomatopoeic syllables—, to have an introduction to the basic playing technique of the gongs and cymbals, and to learn the drumming figures played during instrumental preludes and interludes. This last task turned out to be the most interesting one, since Fan *laoshi* chose the same aria I was studying both with Li *laoshi* and Song *laoshi* (Table 2), so I obtained a comprehensive understanding of one representative jingju aria from the three essential components of its musical dimensions, namely singing, instrumental melodic accompaniment and percussion accompaniment.

Besides the lessons arranged for me, I had the opportunity to engage with the NACTA community in another less mediated, more casual, but very informative manner, in this case as an observer. Since I was living in campus, I had the opportunity to observe and understand who are the young people who decided to take on this, for most of the contemporary society, out of date and marginal profession, and what it involves to be trained as a jingju top professional performer. Informal conversations with some students—including foreign students—contributed to my understanding of the role of this genre in contemporary China—and abroad—, how it is perceived and valued by young generations of artists, and how they envision its future. In order to compare my own experience with the training received by NACTA students I asked permission to attend courses from the standard curriculum of the Jingju Department, specifically to a type of course known as 剧目课 *jumu ke*, repertoire class. In these courses, which carry the central weight of the training for actor and actress students, they receive a comprehensive training on selected plays including the four skills which jingju actors and actresses should master, namely singing, recitation, acting and acrobatics (Section 4.1). Thanks to the help of the Office of International Relations, I was granted access to attend one lesson for first year *laosheng* students and another one for second year *dan* students. In the first one, I luckily attended a session where an aria was taught, and where I could verify that the teaching method was the same as the one used by Li *laoshi* in my own lessons. The four students—including a female one—sat on a row in front of the teacher. Firstly, the students were asked to sing the aria they were studying in unison, including the previous recitation section. The teacher, as Li *laoshi* would do, sang the instrumental prelude, marking the tempo in this case with a closed fan over the table. After few general comments, he asked for a volunteer to repeat the same solo. In this case, the teacher frequently interrupted the student to correct problems. These problems belong to the same categories as the ones Li *laoshi* aimed to correct from my singing, namely pronunciation, intonation and expressivity. As in my own lessons, no much verbal explanations were given, the teacher would just demonstrate the correct way of performing a problematic passage, asking the student to imitate as many times as needed to achieve the desired result. In the class for students of the *dan* role type, a scene focused on physical acting was taught, even thought it included some singing. As with the singing, physical acting is taught through imitation, with the students behind the teacher and imitating her movements, all of them facing a wall covered with mirrors. The teacher would then let the students perform the scene by themselves, and she would interrupt to correct problems. In occasions, the teacher demonstrated alone, and most of the students video taped this demonstration with their cell phones.

From informal conversations with students I learned that most of them received their previous training in professional secondary schools (中等职业学校 *zhong deng zhiye xuexiao*) specialized in jingju performing for both actors or actresses and instrumentalists, and that many of them were in fact trained in the secondary school affiliated to NACTA,[3] located in Beijing. In order to observe how beginner students learn jingju arias, I asked for permission to attend repertoire classes in the affiliated secondary school, and I was granted access to a *dan* and a *laosheng* class. Repertoire classes are also the core education that students in this professional secondary school receive, complemented with reduced versions of the general courses taught in general secondary schools, as one teacher whom a could interview explained to me. The teaching method was exactly the same I observed in NACTA and experienced myself with Li *laoshi*, based on imitation of the teacher, with interruptions to solve problems by demonstration and further imitation.

This stay at NACTA also offered me the opportunity of simply attending many live jingju performances, which is an unavoidable experience in order to develop appreciation for the genre. Besides interacting with faculty, students and teaching activities, NACTA also offers a great opportunity for attending jingju performances. As I learned from conversations with the students, those who excelled in the repertory class were given the opportunity to offer a dress rehearsal (彩排 *cai pai*) of the scene studied in that class in the smaller of the two theatres available in the academy. These rehearsals by all means are full performances, with live instru-

[3] 中国戏曲学院附属中等戏曲学校 *Zhongguo xiqu xueyuan fushu zhong deng xiqu xuexiao* Secondary school of xiqu affiliated to the National Academy of Chinese Theatre Arts (http://www.gxfz.org/)

mental accompaniment by their fellow students, and all the required costumes, props and background actors and actresses, also performed by their fellow students. These rehearsals were open for free to the public, mostly consisting of classmates and some elderly jingju lovers. I attended to all the dress rehearsals of which I knew. Besides NACTA, Beijing is one of the reference cities in the world of jingju, besides Shanghai and Tianjin. The city has some of the most important xiqu theatres in the world, especially 长安大戏院 *Chang'an da xiyuan*, the Chang'an Grand Theatre,[4] and 梅兰芳大剧院 *Mei Lanfang da juyuan*, the Mei Lanfang Theatre,[5] this one being the house of the 国家京剧院 *Guojia jingju yuan*, the National Peking Opera Company,[6] offering performances of the highest quality. When the time—and the budget—allowed it, I also visited these theatres for performances of full plays.

As a result of this field work in NACTA, the most obvious conclusion, related to my research goals, is that, still in the 21st century, in one of the highest institutions for jingju training, the main method for teaching and repertoire transmission is the traditional 口传心授 *kou chuan xin shou*, literally 'transmitted by the mouth, taught by the heart.' The goal of this method, at least as it is used in NACTA regarding singing, is to achieve that the student imitates as faithfully as possible his or her teacher. As a consequence, the students, and for that matter jingju actors and actresses in general, do not need to be conscious of the elements of the jingju musical system being performed, but only of the model set by the teacher. In conversations with several students, and one faculty member, they admitted not being quite sure what *erhuang* and *xipi* really implies for the melody they sing, and that they recognize them mostly by the melodic motive played by the jinghu to cue the singing entrance, which is specific for each combination of *shengqiang* and *banshi*. Consequently, jingju actors and actresses show not owing an explicit knowledge of *erhuang* and *xipi*, and from the observation and experience of the training method, it seems that this knowledge is not required for a successful performance.

4 http://www.changandaxiyuan.cn/

5 http://www.bjmlfdjy.cn/. I use the English translation provided in its website.

6 http://www.cnpoc.cn/. I use the English translation provided in its website.

Explicitly asked about this issue, Li *laoshi* argued that a professional jingju actor or actress should be able to sing new lyrics in either *xipi* or *erhuang*. Encouraged by this claim, I decided to investigate the implicit knowledge that students have of *shengqiang*. In order to carry out an initial exploration of the matter, I designed a small experiment. The goal is to provide a student with a piece of lyrics he or she never saw before, and ask him or her to sung them on the spot either in *xipi* or *erhuang*. I contacted a student from the xiqu literature department, and asked her to write for me two pairs of couplets following the poetic rules, to which she happily accepted and fulfilled in just few hours (all the communication was done through the social media app WeChat, she politely declined my invitation to meet personally). The aim is to ensure, on the one hand, that the student asked to sing the lyrics had never seen them before, so he or she can not simply sing an already learned melody, and on the other hand, that the lyrics meet all the requirements to be comfortably sung in jingju. I asked some students from the jingju department if they could dedicate few minutes of their time to help me with a short experiment. I did not tell them in advance the content of the experiment, so that they could not prepare in advance a general melody. When I met the first *dan* student and asked her to chose one of the two pieces of lyrics and sing them in either *xipi yuanban* or *erhuang yuanban*, she directly declined to even try to do it, arguing that, she not only does not have the skill, but that she is not supposed to have it, since this is a task for the students of the Music Department—where jingju music composition is taught. The second *laosheng* student had the same reaction. After some conversation, in which I encouraged him just to give it a try, he agreed of using the melody from another aria, but even in this attempt he stopped after few characters and declined going on, which I accepted. I sensed that both students, in spite of their first warmth towards my request for help, felt quite uncomfortable once they knew what I wanted from them. Having listened to the arguments of these two participants, I decided to cancel the experiment. Li *laoshi* felt very disappointed with the skills of these young generation jingju artists.

From all the aforementioned experiences, I came to realise that the working knowledge about *shengqiang* might be active among jingju music composers, so I applied for a meeting with a faculty member of the

Music Department who teaches composition. They scheduled one session for me with 沈鹏飞 Shen Pengfei *laoshi*, former jinghu player, active and awarded first national level (国家一级作曲 *guojia yiji zuoqu*) composer of new jingju plays, and jingju music composition teacher in the music department. We met just the day before leaving NACTA. Shen *laoshi* graciously received me in his office, invited me to a cup of tea—and cigarettes, which I thankfully declined—and engaged in a lively conversation for several hours. When I explained to him my research goals, he passionately described to me what is his teaching and composing method, and interestingly analysed with me fragments of what he considers to be the best jingju music, interestingly enough, the scores of the revolutionary plays from the Maoist era. During this conversation, I gained two valuable pieces of information. Firstly, the reference books that, accordingly with Shen *laoshi*, are commonly acclaimed as the reference sources for the study of jingju music (Liu_1 1992, $Zhang_5$ 1992), which became two of the main references for this thesis. Secondly, at some point during the conversation, I explained to him my attempted experiment. When he saw the lyrics I had shown the students, Shen *laoshi* immediately started singing them in *erhuang* first, and then in *xipi*. He even tried with different *banshi* and role types. This reaction confirmed what the students had told me about who is in contemporary jingju responsible for singing melody creation, the composers. It seemed plausible that it was these artists who hold a working, explicit knowledge about *shengqiang*. Sadly, I came to this conclusion the day before leaving the field.

With this outcome in mind, I applied for a second stay at NACTA, this time with the aim of studying with a jingju music composer. I was granted this opportunity two years later, when I was able to visit NACTA from February to July 2016. According to my research needs, the Office of International Relations arranged for me a weekly two hours session of jingju composition with Shen Pengfei *laoshi*. In order to benefit at most from my stay at the academy, and since the core subject of my visit was limited to two hours a week, I applied for continuing improving the *laosheng* singing and jinghu playing skills I started developing in the previous stay. They arranged for me four hours of lessons a week again with Li Zhengping *laoshi*, and two hours of jinghu lessons a week in this case with a graduate student, 庄璇 Zhuang Xuan—who refused to be addressed as *laoshi*. I was also allowed to audit the course 中国传统音乐概论 *Zhongguo chuantong yinyue gailun*, Introduction to Chinese traditional music, taught by Xiong Luxia *laoshi* to first year musicology students.

The main objective of this second stay at NACTA was to learn about the knowledge about *shengqiang* and its use by jingju music composers, and therefore Shen *laoshi*'s lessons were the main focus. In the first lesson, Shen *laoshi*, who luckily still remembered me, designed a plan for the whole stay. He would provide me with real pieces of lyrics, from the libretti on which he himself was working on, and would let me compose the music for them according to different combinations of role types, *shengqiang* and *banshi*. Specifically, the plan was designed for composing for *laosheng* and *dan* role types, *erhuang* and *xipi shengqiang* and *yuanban* and *manban banshi*. I would start with all the arias of *erhuang* and then move to *xipi*, starting with *laosheng* and then moving to *dan* in each case, and composing first *yuanban* and then *manban*.

During that first session, he gave me some general comments about how to infer the melody from the lyrics, the influence of the linguistic tones and the general schema of cadential notes for the first combination to be attempted, namely *laosheng erhuang yuanban*. In order to come up with a fitting melody, I should draw on two sources. The first one was Zhang$_5$ Zhengzhi's manual (1992). Zhang has been his own *laoshi*, Shen *laoshi* himself had studied with this very manual, and this is the one he suggests to his own students. The second source were selected arias for each of the studied categories, which I should memorize beforehand. For the case of *laosheng*, I was suggested to take Yang Baosen's performances as reference (Xu$_1$ 2008). To write down my compositions, I was asked to use A3 paper in landscape position and write both jinghu accompaniment —which I could directly copy from any source—and singing melody in one single line using *jianpu* notation (Section 4.1). From the second session on, the lessons consisted in the correction of my compositions. Shen *laoshi* would sing my lines and whenever a melodic phrase or cell was not of his approval he would write one or several variants that would fit better to his musical understanding. However, the explanations of why such variants fit better than my own were minimal. In many occasions, he would sing the new line aloud hoping for me to notice the improvement. In other cases, he would refer to the linguistic tones, although with the time I realised that the solutions were not consistent and that he would refer in different occasions to different possible realizations of the same tone category (see Section 4.2). For more theoretical explanations he would refer to $Zhang_5$'s manual. Occasionally, Shen *laoshi* would even correct the jinghu line that I copied from a printed source, arguing that that phrase sounded too out of date or would not fit in that specific context.

During the lessons, and while a personal relationship was been established between the two of us, I started to become his own research object, and in many sessions we spent a good while of the time talking about his or my own personal life. Through this conversations I learnt a lot about the life of jingju performers from the 50s onward, since his father was an acclaimed drum master. I learnt that he had spent many years as a professional jinghu performer, and that he had developed his compositional skills from this performing experience, by learning by heart a very large repertory of plays. During his formal training as a composer, besides the jingju music theory he learnt from $Zhang_5$ Zhengzhi, the subjects with which he widened his skills were mostly harmonization and orchestration for Western orchestra. I also learnt that the method he was applying in my lessons is the same he applies in his classes for NACTA students. The time invested in talking about me, I somehow felt it as a fair retribution. Besides the time dedicated to these conversations, Shen *laoshi*'s very busy schedule, with numerous administrative and political obligations inside and outside the academy, resulted in several sessions being canceled. As a result, only the content for *laosheng erhuang yuanban* and *manban* was covered at the end of my stay in NACTA.

Besides Shen *laoshi*'s lessons, singing classes with Li *laoshi* and jinghu classes with Zhuang Xuan did not offered new insights about my research goals, but improved my overall understanding and appreciation of the genre. Li Zhengping *laoshi* continued with the same method he used in the previous stay, we reviewed some arias previously studied, and learned new ones (Table 2). With Zhuang Xuan I reviewed previous arias and learned new ones (Table 2), and also learned some jinghu *qupai*. She put emphasis on the bowing technique, with the aim of achieving a good tone quality. According to her understanding, a good tone quality and properly articulated bowing technique are preferable over a richly ornamented melodic line, which was my previous intuition. This concept importantly changed my appreciation of the instrument. Finally, Xiong *laoshi*'s course on Chinese traditional music was also illustrative about the teaching method of musicological issues in NACTA. As it was my experience in other similar courses I had attended previously before starting this PhD in other Chinese institutions,[7] an essential teaching method is the so-called 'imitative singing' (*mochang*), that is, studying a genre by learning to sing one or several representative songs by 'imitating' the original style, that is, paying attention to as many characteristics as possible of that style —this method resembles a simplified application of Hood's proposal for achieving bi-musicality. In the lessons about xiqu, mostly focused on jingju, Xiong *laoshi* handed out copies of several plays, which she would let the students—myself included—sing in turns repeating her demonstration. She would interpolate comments about metre, rhythmic distribution of characters, cadential notes and melodic motives. Interestingly, in one session Xiong *laoshi* performed in class a comparative analysis of several lines of one *xipi yaoban* aria, through which she pointed out the pitches that are maintained throughout the lines, and which she claimed formed the melodic identity of this *shengqiang* and *banshi* combination. The students were encouraged to perform such analysis—which she called Schenkerian—on their own. However, the more detailed analysis she discussed in class was about one aria from the revolutionary play 《杜鹃山》 "*Dujuan shan*", *The Azalea Mountain*, in which she illustrated the innovations this composition presented in order to convey the content. Sadly, Xiong *laoshi* told me that she has not published any paper on those comparative analysis yet, and that this was still a class exercise.

Besides these formal learning activities, I could also engaged to the same informal activities that I experienced in the first visit to NACTA, such as informal conversations with students, attending repertoire classes, both in the academy and in the affiliated secondary school, attending dress rehearsals, and this time also previous rehearsals, and going to Beijing jingju theatres. During this stay, I could also carry out a few formal interviews to two undergraduate actor and actress students, a graduate actress

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[7] I spent one year as visiting student in the Musicology Department of 中央民族大学 *Zhongyang minzu daxue*, Minzu University of China (2009–2010), and another one in the Musicology Department of Shanghai conservatory of music (2010–2011).

and Zhuang Xuan herself. Through these interviews, among other aspects, I explored the development of creative skills through their training in NACTA, and their answers confirmed what I had learned through observation in my previous stay. Their goal, at least at this stage of their career, was to excel in the performance techniques developed by the historical masters as taught by their teachers. When I referred to the creativity that characterized those masters and if they are encourage to develop such skill during their training, they simply answered that they would not dare to compare themselves to such great geniuses. An unexpected finding from these interviews is another possible reason for the refusal of those students to engage in my preliminary experiment during the previous stay. Most of the hesitations of these students to participate in the interviews, or to answer certain questions that would imply some judgment from their side about their training, were based in a fear of misrepresenting or putting in a bad place the institution or, even worse, their teacher, as they explicitly mentioned. Therefore, those students who in my first stay at NACTA declined to participate in my experiment might have been felt inhibited for fear of a bad performance that would reflect poorly, from their point of view, upon the academy. This is not a fear for reprisals, but based on deep respect, which is nurtured through this constant process of imitating their teachers, who become models not only of artistry, but of general civil behavior. This deep, and to my understanding, sincere respect for the teachers is ostensible from the very demeanor they show to them. As a result of this behavior, teachers are very rarely questioned, even for matters of mere lack of understanding. I felt during my lessons with my different teachers that this was the behavior expected from me, and it constrained my crave for more answers, since at certain points I could sense that I was going beyond the expected boundary with my questions.

As in the previous stay in the academy two years earlier, this second experience in NACTA was highly valuable for deepening my knowledge of jingju as an art form and as culture in contemporary China. However, in terms of my specific research goals, even though it was more productive than the previous experience, it did not fulfil my expectations. The main outcome was the realization that the concept of *shengqiang* is not further verbalized or made more explicit than it is already done in state of the art musicological literature. Composers are in fact in charge of creation of music for new jingju plays. But when it comes to the elements of the traditional jingju musical system, the main source of information is the cumulative exposure to the music by memorizing and imitative singing of representative arias. On top of that, contemporary composers, as individual creators trained in a methodology that strives to achieve originality, do not limit themselves to preexisting musical materials and rules, but expand them in order to express their own personality. The fact that Shen *laoshi* occasionally even corrected the jinghu lines I copied from printed sources might indicate that his personal composing style is part of his criteria for evaluation. Or the fact that both Shen *laoshi* and Xiong *laoshi* praised revolutionary plays as great achievements in jingju music history showed how much innovation from traditional models is valued in contemporary jingju music creation. A deeper understanding of *shengqiang* remained to be found in the music itself, but now I knew the reasons for this situation.

3.3. Computationally extracted information

One of the goals of this thesis, as described in Section 1.2, is to study the opportunities that computational tools might bring to the study of jingju music, and more specifically, of jingju *shengqiang*. As also explained in Section 1.3, this thesis has been carried out in the framework of the CompMusic project, which has motivated this methodological approach for my research. When I first arrived to this project, I had no previous training on computer science or any of its subdisciplines related to music research. I joined the project with the duty of providing with the musicological information about jingju that was needed to fulfil the research requirements about this music tradition. Understanding these requirements implied the development of a working knowledge about the principles and method commonly used by these disciplines. I achieved this knowledge mostly in a practical way, by continuous interaction with other members of the CompMusic project, with whom I necessarily collaborated for the fulfilment of the project's goals.

During this learning process, and from the review of the current use of jingju music from computational methods offered in Section 2.2, I arrived at two important conclusions. Firstly, gaining new knowledge about the researched music is not one of the main objectives for the involved researchers. In most cases, their aim is to push forward the state of the art for a given method or technology, for which jingju music poses new challenges. On the other hand, this work is frequently carried out by teams of researchers, in a collaborative effort that brings together specialists in different techniques, methods or even disciplines. Indeed, during the development of my research, I collaborated with other members of the project for many tasks, whose results have been published (Caro et al. 2014, 2015, 2017a, 2017b, 2018, Dzhambazov et al. 2016, Gong et al. 2017c, Srinivasamurthy 2014a, Zhang_1 et al. 2014, 2015, 2017). However, the research undertaken for this thesis was aimed at achieving new knowledge about the its research object, therefore, the computational tools used for this work should contribute to that goal. During the collaborations with fellow engineers, I realised that the state of the art technologies, originally developed for addressing tasks for music traditions with very different characteristics than jingju, did not produce enough satisfactory results for been utilized in this research—as I describe in more detail at the end of Section 5.1. Therefore, the use a computational approach was limited to the skills I was able to achieve during the development of this research work, so that I could develop a series of tools specifically tailored for the goals of this thesis. Necessarily, none of these tool will rely on the complex mathematical models that underlie the research tasks described in Section 2.2.

In this process, I acquired working knowledge of two important tools. The first one is Python. This programming language is the commonly used one for the development of all the software produced in the CompMusic project. Therefore, knowledge about this programming language was necessary for a useful and productive interaction with other members of the project, as well as for understanding and testing the software they were developing. Secondly, once I concluded that my research will draw on symbolic data—for reasons also explained at the end of Section 5.1—I also acquired working knowledge of music21, self-defined as “a toolkit for computer-aided musicology.”[8] With these two tools, I was able to write my own code to process and automatically analyze machine readable scores.

[8] http://web.mit.edu/music21/

Consequently, in order to satisfy the scientific motivation that impelled the research presented in this thesis, I developed a series of computational tools in Python (v3.5.2) and using music21 (v3.1.0) as the main software for processing and analysing machine readable scores of jingju music. Due to my lack of training on computer science, I was not able to develop any mathematical model for high level exploitation of these data and tools. The goal of the code I wrote hence is to extract statistical information from the collection of the machine readable scores. As for the case of comparative analysis, an inspiration also for this approach was Yung's analysis of Cantonese yueju (1989). For the study of the linguistic tones (87), but especially for the analysis of the aforementioned concept of *sin* (120–121), the author produced a series of charts with statistical information about these objects, from which he concluded certain defining characteristics. However, Yung's analysis are manually done—and manually presented—, thus limiting the scope of his analysis. Having at my disposal the capability of automatically extracting statistical information from a large collection of data, allowed me not exponentially expand such quantitative approach, in terms of number of analysed data, types of extracted information, accuracy of the obtained results, and clarity of the presented plots and tables. The specific information required for the goal addressed in this thesis is informed by the characteristics of the jingju music system, as described in Chapter 4. The resulting code is described in detail in Section 7.2, and the obtained results are all appended to this thesis in Annex 2. Besides, they are all accessible, together with the code, in the thesis' companion web page.

If the goal of the computationally extracted information is to support and expand the results of the main method of this thesis, namely comparative analysis, once I acquired the aforementioned skills I realised that research tasks for which not computational approach was previously proposed can be also addressed with these tools. In this thesis I present one these tasks, directly related to the analysis of melodic identity in jingju, and whose computational analysis was not an initial objective of my research, but the result of the quantitative 'mindset' I developed in this learning process. This task is the relationship between linguistic tones and melody. The new objective was to contribute with statistical and quantitative information to a research task for which not empirical approach had been proposed in the state of the art literature. After a first exploration using audio recordings (Zhang$_1$ et al. 2014, 2015), whose results were not fully conclusive, I decided to benefit both from the symbolic data and my skills to approach the topic from machine readable scores. The results of this task is presented in Chapter 6, where a detailed description of the code is offered. This code is also accessible in the thesis' companion web page.

3.4. Conclusions

The methodology proposed in this thesis draws mainly on comparative analysis, informed by fieldwork experience, and supported and expanded with statistical and quantitative information obtained with the use of computational tools. The combination of these different methods raised the question of the disciplinary affiliation of such methodological framework.

Ethnomusicology is a field whose definition is still a matter of discussion (Nettl 2005: 3–15). One of the most influential definitions arguably is the one proposed by Merriam as "the study of music in culture" (1960: 109). Still today, the Society for Ethnomusicology (SEM) states that

> [e]thnomusicology is the study of music in its cultural context. Ethnomusicologists examine music as a social process in order to understand not only what music is but what it means to its practitioners and audiences.[9]

If SEM can be taken as representing the view of the USA academy, a recent discussion paper resulting from a strategic workshop organized by the European Science Foundation's Standing Committee for the Humanities entitled *Musicology (Re-) Mapped* asserts that "*Ethnomusicology* deals today with all music of the world studied in its cultural context as a human social and cultural phenomenon" (Cuthbert 2010: 7, uppercase and italics from the original). As pointed out in Section 3.2, fieldwork is considered as a defining trait of the discipline and its most representative methodology. For this thesis I drew on fieldwork as a method learned from my background in ethnomusicology, and indeed it was used to learn about the "human social and cultural phenomenon" that jingju music is. However, this learning is not the goal of this thesis, but just a means to inform the

[9] https://www.ethnomusicology.org/page/AboutEthnomusicol

appropriateness of the proposed research question and method. Moreover, the results of the fieldwork research, even though of a great value for the understanding and appreciation of the researched music tradition, did not provided essential knowledge about the specific research task, namely the melodic identity of jingju's two main *shengqiang*, *erhuang* and *xipi*, but about which importance it holds for contemporary performers and composers, and who and how stores this knowledge nowadays. I understand hence the use of fieldwork as an auxiliary method in the general methodology proposed for this thesis, and consequently, even though I acknowledge the influence of ethnomusicology in the research here presented, I do not consider it as essentially ethnomusicological work.

The use of computers for music related research has been referred to with a great variety of names: computational musicology, music computing, music informatics, digital musicology, or MIR,[10] to mention the most common ones. Both the terms MIR and computational musicology appeared in the late 60s, respectively used in a 1966 paper by Kassler and a 1967 paper by Logemann (Burgoyne et al. 2016: 215). These two disciplines, even though they overlap in many research goals and approaches and draw on each other for methodological inputs, remain as independent fields (Volk et al. 2011, Wiering and Benetos 2013, Burgoyne et al. 2016). The discipline of MIR is defined by Downie as

> a multidisciplinary research endeavor that strives to develop innovative content-based searching schemes, novel interfaces, and evolving networked delivery mechanisms in an effort to make the world's vast store of music accessible to all. (2004: 12)

According to this definition, research in MIR is considered as having a clear applied character and being "strongly task-oriented" (Burgoyne et al. 2016: 213), aimed at addressing needs for users of musical digital data. In this sense, and as its very name indicates, MIR is aligned with the general field of information retrieval, developed as a subdiscipline of computer sciences (Müller 2007: VII—VIII).

Regarding computational musicology, this discipline has not found yet such as coherent definition and articulation as MIR. An analogue discipline, at least by name, such as computational linguistics has developed a

[10] This acronym is also used for referring to Music Information Research.

research field of its own. The Association for Computational Linguistics defines that the field's goal is "providing computational models of various kinds of linguistic phenomena,"[11] and to this goal university departments and specialized conferences and journals were established. Even though Bel and Vecchione announced in 1993 the emergence of computational musicology as a "new (transdisciplinary) domain" (1993: 2), the use of computational tools for musicological work has not developed yet an epistemology of its own, but remains as a methodological approach to existing research tasks (Volk et al. 2011). In 2005, Nicholas Cook even wondered if "the opportunity will be missed" for the formation of a new discipline in the intersection of computer science and musicology, as it was the case in the 1980s with the establishment of music psychology in the intersection of musicology and psychology. He points to the lack of engagement of many musicologists with information science as the main reason for this situation, and even argues that "it might be a good idea if we stopped talking about 'computational musicology' at all, and instead just talked about doing musicology with computers" (2005).

Meredith (2016) observes another point of conflict for the establishment of a research area which uses "mathematics and computing to advance our understanding of music (and, indeed, our understanding of how music is understood)" (v), in the great variety of names given to this area, each of them signaling a subdiscipline of its own (interestingly, Meredith proposes a new one, computational music analysis). The author argues that "[w]hat is more remarkable is how little communication and interaction takes place between these subdisciplines and, indeed, how much disagreement can arise when such interaction does occur" (v).

Probably one of the most widespread of those different names is digital musicology. This research area can be understood as the subdiscipline of the digital humanities which engages with musicology, or more in general, music related research tasks. However, as in the case of computational musicology, the definition of the field has not found yet a standard formulation. The very field of digital humanities remains diffuse in the limitation of its scope. In the monograph *A Companion to Digital Humanities*, Hockey avoids defining the field, whose origins she finds in humanities

[11] https://www.aclweb.org/portal/what-is-cl

computing. Regarding the definition of humanities computing however, the author argues that "[s]uffice it to say that we are concerned with the applications of computing to research and teaching within subjects that are loosely defined as 'the humanities,' or in British English 'the arts.'" (2004: 3). The *Companion* includes a chapter entitled "Music," but the term digital musicology is not used throughout the book. In this chapter, Fujinaga and Weiss, even though in their review of the different "computer applications in music" (2004: 97) briefly mention the use of these applications by music historians and musicologists, mainly focus on the data, either in terms of generation, management or gathering of digital data for the creation of databases. The focus on applications and data brings the scope of digital musicology closer to MIR. And indeed, in the reedition of the *Companion* (where the term digital musicology still is not used), the chapter devoted to music is entitled "Music Information Retrieval" (Burgoyne et al. 2016). Notwithstanding this, the term digital musicology is becoming consolidated. The International Musicological Society hosts a study group for digital musicology. The group's mission statement[12] describes that

> [o]riginally concentrating on automatic processing of musical data, the focus area has widened to include the many different kinds of music-specific computing such as digitalization of musical heritage (both notation and musical audio), digital editing, advanced searching and access to online materials, computational modeling of music, automatic analysis, interactive environments for music research, and general issues of data-richness and technology adoption.

This statement shows how the area has evolved from a main focus on data to more musicological research tasks. The recently founded journal *Frontiers in Digital Humanities* devotes one specialty section to digital musicology. The description of its scope[13] states that

> Digital Musicology is a forum for musicological research engaged with digital technology. This section uses the term "musicology" in its broadest sense: including more traditional approaches, such as ethnomusicology, historical musicology, and music theory, as well as newer ones, such as

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[12] https://www.musicology.org/networks/sg/digital-musicology

[13] https://www.frontiersin.org/journals/digital-humanities/sections/digital-musicology#about

> music information retrieval, music library studies, and music perception and cognition.

This statement brings digital musicology closer to computational musicology, and it can be argued that even overlaps almost completely the two disciplines.

This discussion about terminology has also a geographical component, and indeed the research here presented is developed in the framework of European academy, which establishes certain criteria regarding the definition and structuring of the discipline of musicology. In the previously mentioned *Musicology (Re-) Mapped* strategic workshop organized by the European Science Foundation's Standing Committee for the Humanities, the discipline of musicology is structured into three subdisciplines, namely historical musicology, systematic musicology, and ethnomusicology. Computational approaches to music research is usually considered as common component of systematic musicology (Huron 1999, Leman 2008). Parncutt (2007), acknowledging that "[s]ystematic musicology is an umbrella term, used mainly in Central Europe," (1) observes that this field is usually broken down into two subfields, namely "humanities systematic musicology, or cultural musicology," and "scientific systematic musicology, or simply scientific musicology," the latter being comprised by "empirical psychology and sociology, acoustics, physiology, neurosciences, cognitive sciences, and computing and technology" (5). In this sense, the field of systematic musicology, in regard of the establishment of an epistemological paradigm at the intersection of computer sciences and musicology, is less specific than the previously reviewed computational musicology or digital musicology.

Finally, in the last years, the term computational ethnomusicology has been gaining presence, especially within the communities closer to computer sciences. Even though the term is already coined in the late 70s by Halmos, Köszegi and Mandler (Gómez 2013: 111), it is George Tzanetakis who is advocating for its relevance in the last years, especially within the field of MIR (Tzanetakis et al. 2007, Tzanetakis 2014). Tzanetakis et al. define the field as "the design, development and usage of computer tools that have the potential to assist in ethnomusicological research" (2007: 3). However, the author points out that he uses the term "'ethnomusicology' to mean 'the study of all the world's musics,' without implying any particular methodology." Taking Parncutt's definition of musicology's research object as the "notated music of Western cultural elites," Tzanetakis et al. define ethnomusicology's research object as "everything else," a view that the authors themselves acknowledge as "naïve" (2007: 4). The authors points out that "[t]he main focus of MIR research has been either modern popular music or classical music," and links the coining of the term computational ethnomusicology to "[t]he need to consider the large diversity of music cultures from around the world" (2014: 113). This definition clearly stands in conflict with the current understanding of the field, as described at the beginning of this section. In fact, Merriam, whose influential definition of the field as "the study of music in culture" has already been mentioned, explicitly affirms that ethnomusicology should be understood "not as the study of extra-European music" (1960: 109), a common assumption in the discipline since the 60s. The term computational ethnomusicology is however promoted from the fields of MIR and computer sciences, as it is ostensible from the special issue that the *Journal of New Music Research* devoted to this discipline. In the introductory paper to this issue, Gómez et al. explain the need of the term by arguing that

> [s]ince the beginning of Music Information Retrieval (MIR) as a field, most of its models and technologies have been developed for main stream popular music in the so-called 'Western' tradition. Over the last few years, there has been an increasing interest in applying available techniques to the study of traditional, folk or ethnic music. (2013: 111)

This definition still draws on the same troublesome concept proposed by Tzanetakis et al., opposing an MIR for "Western" musics and a computational ethnomusicology for the others. However, Gómez et al. have deeper expectations for the discipline. They hope that the purpose of computational ethnomusicology is not merely providing with mere tools for the ethnomusicological work, but, arguing that "[c]omputer models can be 'theories' or 'hypotheses,'" they hope for this discipline to bring out a "new mental framework that helps to restructure problems and perceive the relationships between their constitutive elements under a different perspective" (2013: 111).

From my point of view, this last argument by Gómez et al. is essential for computational musicology or digital musicology to be established as a research discipline of their own. The use of computational approaches should not be a mere methodological expansion of the existing field whose research objectives, objects and tasks remain unaltered. As a consequence, these new disciplines should not merely imply the achievement of traditional musicological goals by methods from the computer sciences, but a true new epistemological paradigm, which, as stated by Gómez et al., addresses a knew branch of knowledge. Regarding this understanding of computational musicology or digital musicology, the work undertaken in the thesis here presented would not lie within the framework of these disciplines. The algorithms developed for this work for extracting statistical and quantitative information from the data do not alter the principles of comparative analysis as explained in Section 3.1, but just support and expand the obtained melodic schemata with such information. Since the focus of this research lies on the understanding of jingju music, without the aim of developing any user oriented application, it could not be considered as belonging to MIR either. Finally, I would not consider the work presented in this thesis as computational ethnomusicology, mainly because, to my understanding, the definition of the field, as proposed by Tzanetakis et al. and Gómez et al., present a distorted vision of ethnomusicology, potentially preventing the implication of specialists from this field.

Taking all these considerations into account, I argue that the methodology designed for this research should be defined as computer aided musicology. In this definition I take musicology in its broadest meaning as "the scholarly study of music" (Duckles et al. 2011), without constrains about the specific research object or method. Therefore, the proposed comparative analysis method for the study of jingju music do not enter in conflict with more concrete specializations of musicological subdisciplines. The use of computational tools, even though presenting a supporting role, links the methodology with other computational approaches to music research. Consequently, the definition of the present work as computer aided musicology explicitly states the influence of those approaches, while maintaining musicology as the central field, understood in a wide enough manner as to encompass the proposed research object and method.

Chapter 4 The jingju musical system

In Chapter 2 I presented the state of the art in the study of jingju music from musicological and computational points of view. Regarding the first discipline, I focused there in the different approaches undertaken by the reviewed authors, finding a well established tradition in Chinese Academy for the description of the musical dimension of jingju, which I assumed as the theoretical framework for this thesis. I present here precisely that framework. The goals are, in the first place, to overview how the jingju musical system, and especially *shengqiang*, is described according to that tradition. Secondly, to establish the theoretical concepts according to which the subsequent analyses (Chapter 6 and Chapter 7) will be framed. And finally, to identify the current gaps in the understanding of *shengqiang*, which this research aims to fill. Since jingju is not an exclusively musical art form, I start with a description of the role that music plays within the genre as a whole, and particularly in relationship with the lyrics. Then I describe in detail three of the most important elements of the jingju musical system, namely role type, *shengqiang* and *banshi*. I conclude the chapter by emphasising those aspects of relevance for the remaining of the thesis, as previously explained.

4.1. Music in a synthetic art form

An essential element of a synthetic art form

During the individual classes that NACTA arranged for me with Li Zhengping *laoshi* shared with me his reflection on jingju art from a lifetime of performing and teaching. Almost in every session he will emphatically point out the three elements that necessary identifies xiqu as a unique art form, and without one of which, we might be enjoying great art, but it couldn't be called xiqu. This three elements are 曲 *qu*, literally, in this context, 'tune,' 程式 *chengshi*, conventions, and 虚拟表演 *xüni biaoyan*, literally 'virtual acting.' All these elements, he insisted vehemently, must always be put to one ultimate goal, *xi*, a term without easy translation, whose original broad meaning can be understood as "entertainment" (Relinque 2002: 8), but which in the context of xiqu should be taken as theatrical performance. This understanding of his own profession reflected that for Li *laoshi*, and as I came to realise, for all their fellow performers and faculty members, jingju mainly was a theatrical art form, in which the actor or actress, by means of these three elements, has the purpose of building a character and developing a story.

However, among these three elements, Li *laoshi* will give *qu* a predominant position. According to his understanding, *qu* had preceded the formation of xiqu, even though once it was formed, it was put at the service of *xi*. Indeed, before xiqu was consolidated in the form we know today,[1] *qu* gave name to a music genre combining singing and dancing known as 大曲 *daqu*, or a homonymous poetic form intended to be sung, and which was the literary base for xiqu. For Li *laoshi*, *qu* stands for the whole musical dimension of jingju, epitomized in singing, but going beyond what is strictly musical and referring to an underlying structuring principle that vertebrates the whole performance. This principle is rhythm. A jingju actor or actress, in Li *laoshi*'s view, has to aim at controlling the performative rhythm, while singing, but also while acting—in fact not sung performance is frequently led by percussion instruments—, what he calls acting rhythm, but even when conceptually developing the story and building the character, what he calls the psychological rhythm.

The three elements that define jingju identified by Li *laoshi* closely resemble those established by the xiqu theorist 张庚 Zhang Geng. With the

[1] The general agreement about the consolidation of xiqu in its actual form is that it happened during the Yuan dynasty (1271–1368) with the genre known as *zaju*. For a thorough description of xiqu history, please refer to Mackerras (1988). For specific aspects of xiqu history, Hai Zhen's work (2003) monographically studies the history of xiqu music, whilst Dolby's volume (1976) is the reference work for its literary aspect.

aim of achieving a more accurate definition of xiqu than the one given by the writer and scholar 王国维 Wang Guowei at the beginning of the 20th century as "telling a story by song and dance," which can be applied to many other theatrical traditions different from xiqu, Zhang proposed in the 80s that the three characteristics that makes xiqu a unique art form are 综合性 *zonghexing*, 虚拟性 *xünixing*, and 程式性 *chengshixing* (Hai 2003: 2–3), respectively the qualities of being synthetic, virtual and conventionalized. Where Li *laoshi*'s understanding slightly differs from Zhang's formulation is in the first characteristic, synthetism. I say slightly because this idea includes the four disciplines that every jingju actor or actress should master, although with a different focus depending on his or her role type. These four disciplines are so widely accepted that they are usually mentioned together almost as a noun: 唱念做打 *chang-nian-zuo-da*, which respectively refer to singing, declamation, physical acting, and acrobatics, this last one including a stylized version of martial arts. Among these disciplines, the first is directly related to *qu*, to music, and the rest are united through the musical, rhythmic principle that embeds jingju performing.

The three elements that according to Zhang Geng or Li *laoshi* define xiqu are intimately related among them, and it is the second one, conventions, which unites them. The technical training of a jingju actor or actress is divided into the four aforementioned disciplines, singing, declamation, physical acting and martial arts. The training consists in mastering the conventions established by tradition for each of these disciplines. And it is through these conventionalized performance, that jingju actors and actresses are able to construct a character, to develop a story, by virtual performing. An acrobatic convention like a somersault landing in the back might indicate that the character has been shot dead, a convention of physical acting like gently touching both cheeks consecutively under each eye indicates that the character is weeping, a conventionalized declamation indicates the gender and age of the character, independently from the gender and age of the actor, and singing conventions indicate the emotional state of the character. The result of this acting procedures is a conventionalized, codified, unrealistic performance, which in no way hinders the artistry. On the contrary, aesthetic appreciation of xiqu consists precisely in the beauty of how the performer delivers these conventions. Instead of a representation, xiqu acting is characterized by A. C. Scott as following a "presentational style," that "can be described both as the creation of actors and an actor's theater" (Mackerras 1988: 118), or as Wichmann puts it, "a performer-oriented theater" (Mackerras 1988: 188).

This presentational, performer-oriented, virtual acting affects every aspect of xiqu, including scenography, since it is practically inexistent. In jingju circles, scenography is usually said to be consistent of "one table and two chairs" (一桌两椅 *yi zhuo liang yi*), and in most of the traditional plays, this is literally the case. And there exists a set of conventions that applies to this table and couple of chairs, so that different positions on the stage create different dramatic spaces. It affects also to costumes and make-up, which instead of trying to depict the character in his or her historical context, are designed in an atemporal, highly stylised, conventionalised manner, to convey to the audience information about the gender, age, social position, and even psychological profile. The virtual, fictional acting through all these conventions are made possible by a general aesthetic purpose that is shared with the rest of Chinese traditional visual arts, known as 写意 *xieyi*. This term is understood by Huang Zuolin as 'essentialism', and is contrasted with 'realism' as "the keynote of Western art" (Wu_2 1981: 24).

From all this it can be concluded that conventions lie at the very core of xiqu performance, as enablers for the achievement of the ultimate aesthetic goal of essentialism. And of course jingju is a clear example of this. Their importance is such that Li_2 Ruru, borrowing the expression from the jingju actress 李玉茹 Li Yuru (1923–2008), entitles them as "the soul of jingju" (2010: 56). These conventions, although for many jingju actors and critics have been considered as a constrain for the development of jingju, for most jingju actors and actresses within the tradition, conventions were precisely the source of creativity. Li_2 argues that "the essence of *jingju* education is to train actors to master as many conventions as possible; the more conventions actors have learned, the more creative they can become"[2] (2010: 57). This is so because conventions are the essential units with which actors and actresses build their characters, and develop the story. The greater mastery they achieve of them, the more tools they

[2] Italics from the original.

own to bring to life in an 'essentialist' way the drama. And as stated previously, these conventions concern all the four disciplines that a jingju performer must master, including obviously singing, which is the focus of this research. In this framework, each *shengqiang* should be understood as the singing convention which deals with melodic material. And according to the argumentation here presented, it is also the main tool for melodic creation. However, the actually sung melody is the result of a combination of a series of conventions, more or less directly related to singing, and with a more or less important influence to it. In the following sections then, I will present the elements that influence melody creation as described in state of the art literature. But before this, since the study object of this research is the vocal singing, I will briefly present how it relates with other musical elements in jingju.

Declamation, instrumental accompaniment, singing

In order to comprehend the function and use of singing in jingju, it is useful to retake the concept of rhythm as an underlying principle that vertebrates the whole performance. Considering this principle, jingju is inherently musical at any time. All the four disciplines that actors and actresses must master, singing, declamation, physical acting and acrobatics, are embedded, in different degrees, into this rythmicity. Each particular convention has a rhythmic component to it. Of course, it is not meant by this that this rhythm is metred, nor even regular, but it is more concrete and closer to the surface than the dramatic rhythm evaluated in literary or cinematographic criticism. Almost all acrobatic movements, most of the physical gestures and many of the recitation patterns are signalled or punctuated by a stroke of one or several percussion instruments. It is symptomatic that the drummer, known as 司鼓 *sigu*, who is the performer that leads the percussion ensemble in particular and the instrumental ensemble in general, is seated looking at the performer, and there is a constant, direct visual communication between them. In fact, the drummer together with the jinghu master, are the only instrumentalists who are credited in performance announcements or recordings credits.

Considering this framework, singing can be understood as a musical intensification of the underlying rhythmic spine. The common term to refer to these passages in jingju is *changduan,* literally meaning "singing section.” This term gives an idea of how these sections are conceived within the whole play. *Changduan* are just the sections where singing occurs, or where it is required because of dramatic needs, within a performative continuum. This conceptualization contrasts with the notion of aria in European opera or lyrical music, which might be the closest notion to *changduan* in this context. In his definition of aria, Westrup states that it signifies “any closed lyrical piece for solo voice (exceptionally for more than one voice) with or without instrumental accompaniment, either independent or forming part of an opera, oratorio, cantata or other large work.” The main difference between *changduan* and aria is that the latter is an autonomous piece, not in performance but in its very conception. Surely jingju *changduan* are usually performed or recorded individually, but in many cases this implies some compromises, since they were conceived within a dramatic continuum.

When introducing the notion of *changduan* to her undergraduate students in the course “Introduction to Chinese traditional music,” Xiong Luxia *laoshi* explained that the typical introduction to a *changduan* consists in a line of declamation, a specific pattern performed by the percussion ensemble, and an instrumental melodic prelude which leads to the actual singing. It was surprising to me that in Xiong *laoshi*’s view a *changduan* is considered to be introduced even before the instrumental ensemble starts to play. She called that introductory declamation line 叫板 *jiao ban*, literally ‘calling the *banshi*’ or ‘calling the metre’, and I have realised that this line is maintained in many occasions, even when single arias are performed. It is common in commercial recordings of *changduan* that they start with this line of declamation, and in the singing lessons I observed in NACTA, it was common to start rehearsing a *changduan* with such a line, followed by an onomatopoeic sung version of the percussion pattern and instrumental prelude (Section 3.2). Even when Li Zhengping *laoshi* was about to teach me a new *changduan*, when he sang it for himself to refresh it, he usually started with this line of declamation. This *jiao ban* line is very insteresting, because it establishes a natural link with the encompassing performance as a whole.

Another noticeable difference with arias is that jingju *changduan* usually include several characters, according to the dramatic context, and indeed the duets between two characters are fairly common, known as 对唱

duichang, literally meaning 'dialogic singing.' On the other hand, it is even more common that, during the singing of the couplets that form the *changduan,* other characters, or even the one who is singing, intervene with elements from the other three disciplines, declamation, physical acting and acrobatics, interventions that continuously link the *changduan* with the performative context. In fact, there is a percussion pattern known as 住头 *zhutou*, whose function is to signal the end of a performance passage with an internal unity (Mu 2007: 341). Only when this pattern is performed, there is a formal signal of the end of a *changduan*.

In a famous *changduan* from the play *Si lang tan mu* 《四郎探母》 (*The fourth son seeks out his mother*), Princess Tiejing 铁镜公主—a *dan* role type—from the enemy Liao kingdom, is trying to guess what it is that is worrying his husband Mu Yi 木易—a *laosheng* role type—who in reality is the general Yang Yanhui 杨延辉 from the Chinese Song kingdom in disguise. Figure 1 shows a structural schema of this aria. The *changduan* begins, as Xiong *laoshi* stated, with a few short declamation lines between the Princess and her maids, then a percussion pattern follows, after which the instrumental prelude starts which leads to the Princess' singing. After the first couplet, which introduces the situation, she starts making her guesses, one per singing line. After each of these lines, it follows a short declaimed dialogue, during which the instrumental accompaniment stops, in which Yang tells the Princess that she didn't guess it right, and why it is so. After four failed attempts, sung in respectively four lines—two couplets—each of them followed by a short declaimed dialogue, the Princess expresses her frustration in a new singing line. Then a passage of physical acting starts, during which the instrumental ensemble plays a short *ostinato* motif called 行弦 *xingxian*, literally 'running strings.' With no words, but just hand gestures, facial expression, and eye movements, the Princess invites his husband to go out to the garden to take some air. There they separate, and from afar, she sees him weeping, which makes her come up with her final guess. Then she calls her husband using declamation, and sings this last guess closing the fourth couplet. After hearing this correct guess, Yang, startled, sings three lines aside expressing his fear about the Princess having guessed that he misses his family. She asked in declamation if the guess is correct, and Yang finishes his sung aside with the fourth line committing himself to reveal his true identity. In

jiao ban: declamation + percussion pattern + prelude			
dan	couplet 1	*daoban*	夫妻们打座在皇宫院，
		manban	猜一猜驸马爷袖内机关。
	couplet 2		莫不是我母后将你怠慢？
			dialogue
			莫不是夫妻们冷落少欢？
			dialogue
	couplet 3		莫不是思游玩那秦楼楚馆？
			dialogue
			莫不是抱琵琶你就另向别弹？
			dialogue
	couplet 4		这不是那不是是何意见？
			physical acting (instr. interlude)
			dialogue
		yaoban	莫不是你思骨肉意马心猿！
laosheng	couplet 5	*kuaiban*	贤公主虽女流智谋广远，
			猜透了杨延辉腹内机关。
	couplet 6		我本当向前去求她方便，
			dialogue
		yaoban	还须要紧闭口慢露真言。
			dialogue
	couplet 7	*kuaiban*	我在南来你在番，
			千里姻缘一线穿，
	couplet 8		公主对天盟誓愿，
			本宫方肯吐真言。
zhutou: percussion pattern signaling the end			

Figure 1. Schema of one *changduan*.
From Shanghai wenyi chubanshe (vol. 8, 1995: 16–26). The third column shows the start of a *banshi*. The whole aria is in *xipi*.

a brief declaimed dialogue, Yang confirms that the Princess guessed correctly, but she cannot do nothing about. She asks him to explain himself, to what Yang replies singing four lines, asking the Princess to swear an oath. And it is only after these two last couplets when the percussion ensemble performs a *zhutou* signaling the end of the passage. The play then continues with a passage of declamation and physical acting (Shanghai wenyi chubanshe, vol. 8, 1995: 26).

This is a rather complex, but not uncommon at all, example of how flexible the structure of a *changduan* can be compared with the standard aria form, and how embedded it is with the overall performance. Of course, there are also cases in which a *changduan* consists only in singing. Just in the same play, the first *changduan* sung by Yang Yanhui consists in nine couplets sung in different *banshi*, with an introduction that follows Xiong *laoshi*'s description, although in this case no *zhutou* is performed to signal the end of the *changduan*, since it is very explicit by the first entrance on stage—with all the performative conventions that it implies—of the second main character, the Princess Tiejing. In this case, the form of the *changduan* is much closer to that of the aria.

Although, as it has been detailed, *changduan* and aria present notable differences in terms of form and conceptualization, in this thesis I will use nevertheless the term aria to refer to jingju *changduan* to ease readability. Besides the aforementioned differences, a *changduan* plays a similar structural and functional role in a jingju play that an aria does in an opera. Both cases are passages of maximal music intensity, which correspond to maximal emotional intensity, and which therefore are the major focus of musical activity within the whole work. Although in the case of jingju, as previously explained, arias are deeply embedded in overall performance, both jingju and opera arias can be taken as musical units, even though for jingju arias this might imply omitting elements from other disciplines than singing. Consequently, and being conscious that terminological precision is sacrificed to a certain extent, I argue that the use of the term aria for referring to jingju *changduan* is operational and conceptually acceptable.

Before moving to the description of the conventions involved in singing, I will briefly describe the instrumental accompaniment. Jingju instrumental ensemble, which used to be called 场面 *changmian*, literally 'scene,' is divided in two sections, the 武场 *wuchang*, literally 'martial scene,' and the 文场 q*wenchang*, 'civil scene,' which are usually known respectively as military and civil sections. The martial section is formed by the percussion instruments. There are five basic percussion instruments, the danpigu drum, the ban clappers, the naobo cymbals and the xiaoluo and daluo gongs, literally 'small gong' and 'big gong.' The first two instruments are played by the same musician, and therefore are known with the conjoint name bangu. In special occasions additional instruments might be added, of which one of the most common is the tanggu, literally 'hall drum,' commonly used to create an atmosphere of royal courts or crowed armies. The bangu player is known as *sigu*, literally 'the one managing the drum,' whom I will call drum master to equate it to the jinghu master, and whose role has been compared to that of the conductor in Western classical orchestras.

An important function of the martial section is to perform *luogu jing*, predefined, labeled patterns with specific musical or performative functions—as, for example, the aforementioned *zhutou*. Some of them are used to signal a specific structural point, related with the whole play or a particular scene or aria, while others are used to rhythmically guide physical acting or acrobatic movements by the performer, or even to set the emotional atmosphere of the scene (Mu 2007). When used to signal an aria structure, they usually mark the introduction, the end, or a change of *banshi*, but they do not concur with the singing. When these patterns are performed, it is only the drum master the one who keeps eye contact with the actor or actress, in order to be able to coordinate the strokes with the actor's or actress' movements, while the remaining three musicians pay attention to the drum master's signals. During an aria singing, the drum master has also to mark the beat, using *ban* strokes to signal strong beats, and drum strokes to signal soft beats. During instrumental sections, like preludes or interludes, he[3] plays a series of ornamented, contrapuntal motives known as 鼓套子 *gutaozi*, literally 'drumming sets' (Liu_2 2011). Although it is usually assumed to be him the one setting the tempo, this is

[3] If in the case of 'civil section' it is common to find female performers, and among students they are even a majority, I have never found any female musician in the 'martial section.' During my drumming classes at NACTA with Fan Qingtao *laoshi*, I asked him if he ever had a female student or ever met a female percussionist in jingju, and he said that he seemed to remember one performer, but he never taught a female student.

the result of a continuous negotiation between the actor or actress, the jinghu master and the drum master, who alternate in leading the tempo direction. In any case, the drum master has always the function of marking the tempo. But even in not sung sections, the drum master is in charge of punctuating the rhythmic spine that Li *laoshi*'s argues underlies jingju performance as a whole, by marking declamation, acting or acrobatics "beats." One or several of the remaining instruments might accentuate this function if needed. They also can be used to sonify atmospheric—rain, night—or emotional—surprise, sadness—elements, by onomatopoeic or codified strokes.

The lead instrument of the civil section, and the most characteristic of jingju, is the jinghu. Its loud, bright and piercing timbre confers jingju to one of its most remarkable sonic identities. The jinghu player is known as 琴师 *qinshi*, literally 'master instrumentalist,' and whom I will call jinghu master. If the main function of the drum master is to sustain the rhythmic scaffolding of jingju performance from its most superficial to the deepest level, the jinghu master is in charge of supporting all the singing content of a jingju play. Traditionally, the jinghu master, in close collaboration with the main actors or actresses of a company, were the ones in charge of melody arrangement for new plays. This collaboration is so close, that great actors and actresses even today only sing on the accompaniment of his or her personal jinghu master. In fact, traditionally there is no standard tuning for the jinghu, but it is set to the vocal range of the actor or actress, within a certain range.[4] This mutual understanding between instrumentalist and singer is crucial since both conceptually perform the same melody, although each of them would vary it according to their own expressive qualities, resulting in a heterophonic texture (Figure 2.b). Its central role in the melodic and timbral identity of jingju is such, that there are specific variants of the instrument for each *shengqiang*, so that jinghu masters usually carry four or five different jinghu in their bags. The jinghu line sustains the singing line as a continuous melodic strain. It generally precedes the singing with a prelude, whose melodic content is determined by the specific combination of role type, *shengqiang* and *banshi*, which includes

[4] Nowadays, standard tunes have been determined for each *shengqiang* (Zhang$_5$ 1992: 32–33), although in actual performance variations are allowed according to the actor's or actress' needs.

a characteristic motif that works as a call for the singing. When the singing line pauses according to the lyrics structure, the jinghu line continues without interruption, linking melodic sections with interludes and covering short singing pauses with brief melodic fillers. Both the instrumental preludes and interludes are known as 过门 *guomen*, literally 'passing gate' (Figure 2.c), and translated by Wichmann as 'instrumental connectives' (1991: 77), while the melodic fillers are known as 小垫子 *xiao dianzi* (Zhang$_5$ 1992: 8), literally 'little cushion' (Figure 2.d). A characteristic feature of jinghu accompaniment is that its melody keeps a continuous brief pulsation, which works as a subdivision metronome for the beats marked by the bangu, and adds a rhythmic component to the continuous melodic stream which uninterruptedly impels the singing. The jinghu line is supported by two plucked string instruments, the 月琴 yueqin and the 三弦 sanxian—also known in jingju circles as *xianzi* 弦子 (Liu$_1$ 1992: 8). They play the same melody as the jinghu line, but in a heterophonic structure. As in the case of the martial section, it is the jinghu master the only musician who constantly maintains eye contact with the actor or actress, while the yueqin and sanxian performers frequently observe the jinghu master's gestures to follow his or her tempo and articulation. The plucked character of yueqin and sanxian creates an interesting complement to the sustained sound of the jinghu. The characteristic tremolo of the yueqin, which plays in the same octave as the jinghu, adds an effect of melodic-rhythmic stream to the accompaniment, and the sanxian, generally playing an octave lower, adds depth to the melody. This three instruments form the traditional ensemble for singing accompaniment. Mei Lanfang is commonly credited for adding a fourth instrument to these, specially for accompanying *dan* singing, the erhu. The one used in jingju is an adapted version that allows to replicate the bowing technique of the jinghu, and is therefore known as 京二胡 jing'erhu, although in jingju circles is referred to just by erhu. It plays the jinghu line in a heterophonic texture and an octave lower, adding a deepening, soothing support to the high pitched timbre of *dan*. Nowadays, the ensemble for singing accompaniment has been extended with low range instruments, specially the plucked string 阮 ruan, in its middle and lower range variants, 中阮 zhongruan and 大阮 daruan, and even violoncello.

Besides accompanying singing, the civil section is also in charge of instrumental passages performed in specific occasions. As seen in the aria from *Si lang tan mu* described previously (Figure 1), the instrumental ensemble played a short *ostinato* motif to accompany a passage of physical acting. These brief, standardised motives known as *xingxian*, literally 'running strings,' and translated by Wichmann as 'action-strings' (1991: 248) are usually played as a melodic background of physical acting passages, generally inserted in arias. They are played repetitively as an *ostinato* for as long as the actors or actresses need to finish their acting movements, and therefore have no predefined duration. Since 'running strings' tend to occur amid singing, they are played by the same ensemble that accompanies the singing. A second form of instrumental passages are individual tunes that work as stand-alone pieces with their own title, and therefore known as *qupai*, literally 'tune labels.' These tunes are performed in special dramatic occasions, such as royal or military parades, banquets, religious or civil celebrations, dance numbers, etc. Some of these tunes are performed by instruments other than the ones mentioned so far, and are therefore categorized by the main instrument playing them. Besides the tunes for jinghu, played by the same ensemble that accompanies singing, there are tunes for a pair of the double reeds 唢呐 suona,[5] for the flute 笛子 *dizi*,[6] usually accompanied by the mouth organ 笙 sheng, and for a pair of the double reed 海笛 haidi and flute dizi (Liu_1 1992: 8-9). Probably, the most commonly played of these tunes is the suona tune named 《尾声》 *Wei sheng*, literally 'tail sound,' which is played to signal the end of a play.

[5] The pair of suona is also the main singing accompaniment for the *suona erhuang shengqiang*. A suona is also commonly used for sound effects, like a horse neighs or baby cries.

[6] A pair of dizi is used as the main singing accompaniment of the *kunqiang shengqiang*.

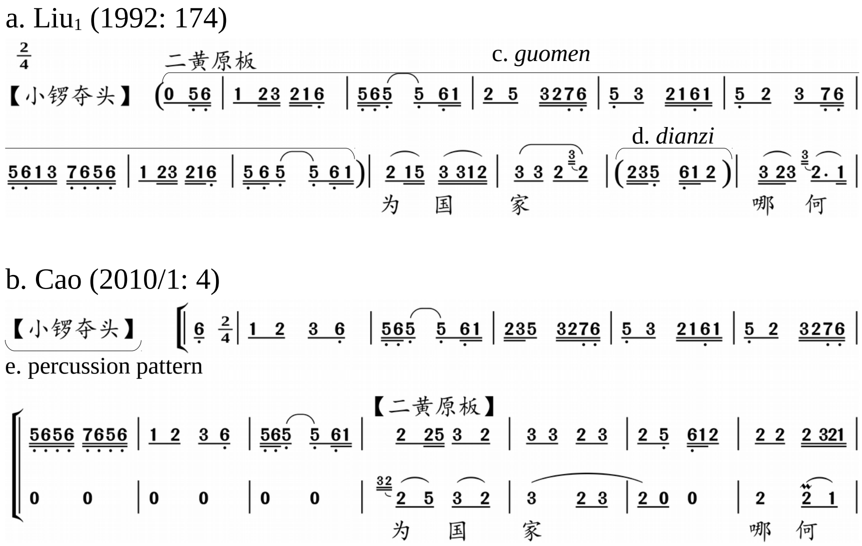

Figure 2. Two notations of the same aria (excerpt).

Finally, I would like to briefly mention some conventions about notation of jingju singing accompaniment. The first convention is not to notate percussion. If the aria is introduced or concluded by percussion patterns, or if one of them is performed during the aria, only the label of the pattern is reflected in the music score (Figure 2.e). The tempo marking and drumming sets performed by the drum master are totally omitted. Only special percussion strokes are notated by means of the set of Chinese characters used for their conventionalized onomatopoeic representation of a percussion stroke. As mentioned previously, a jingju aria conceptually consists in a single melodic line. The instrumental accompaniment performs the same line in a heterophonic texture, and also links the different singing sections and even fill short pauses, resulting in a continuous melodic stream. When the accompaniment is written down in music notation, these characteristics are used to simplify the notation. For the instrumental accompaniment, only the jinghu line is notated, since the rest of the civil section instruments are conceived as playing the same melody. The system that is nowadays universally used for notating all traditional music in China, including jingju, is the numbered notation known as *jianpu*, literally 'simplified notation'[7] (Figure 2). The jinghu line can be notated in an individual notation line parallel to the singing one, where the instrumental sections are filled with rests (Figure 2.b). But also, both the jinghu and singing line can be notated in a single notation line (Figure 2.a). In this case, only the prelude, interludes and melodic fillers, that is, everything from the melodic stream that is not played together with the singing line, is notated in the same line along with the singing, but putting them between brackets, and usually in a smaller type size in order to clearly set it apart from the singing line. This type of notation clearly reflects how a jingju aria's melodic material is conceived as a unique line.

4.2. Relationship with the lyrics

In a theatrical art form as xiqu, in which performance is built around a dramatic story, lyrics hold an essential position as the most direct means for delivering such story to the audience. Some early genres, such as zaju or kunju, counted with libretti written by scholars and therefore achieved a high literary value. In fact, the plays performed in kunju belong to a genre known as 传奇 chuanqi, literally 'transmission of the extraordinary,' which originated already during the Tang dynasty as short stories evolved into dramatic scripts. These libretti were printed out and enjoyed as a literary reading. In fact, some of them were even written without the aim of being performed on stage (Idema 2001: 796). Other genres of more recent formation, specially those known as 地方戏 *difang xi*, literally 'local theatres,' don't draw on written scripts, an even improvise the lyrics along a predefined general schema using a formulaic composition method, as Yung has thoroughly described for the case of Cantonese yueju (1989).

[7] This system shares the basic principles of staff notation in that it notates pitch and duration. Pitch notation is based in a movable Do system, by which each of the seven degrees of a tonal major scale is represented with a number from **1** to **7**, and the specific key is indicated at the beginning by assigning a pitch class value to the first degree, so that **1**=C indicates C major. Lower or higher octaves are indicated by dots respectively under or over the numbers. Duration notation is based in the metrical system of tonal music, so that the time signature is indicated at the beginning and the measures are marked with bar lines. Each number is assigned the default duration of a crotchet, each underline divides its duration value by 2, and following hyphens indicate the prolongation of the note for as many crotches as hyphens. Dots and tuplets are used in same manner as in staff notation. Rests are notated by **0**. Grace notes are notated by superscript numbers. Accidentals, slurs, ties and ornamentation symbols are used as in staff notation.

The situation of jingju scripts in its early stages is closer to the one of Cantonese yueju than to kunju, although at the beginning of the 20th century it is notorious the collaboration between scholars and actors for the creation of new scripts with remarkable literary quality. The collaboration between the scholar Qi Rushan and Mei Lanfang is probably the best known one (Fu 2007). However, independently from how it was created, the script has a direct influence in the music arrangement. During my classes with Shen Pengfei *laoshi*, he explained to me, as to the rest of his jingju music composition students, that the first step for setting lyrics to music is to recite them aloud (朗诵 *langsong*), paying careful attention to three elements, namely 语意 *yuyi*, meaning, 语气 *yuqi*, mood, and 语势 *yushi*, intonation, an approach that is also suggested in the same terms by the also composer Zhang$_5$ Zhengzhi (1992: 8). The goal of this approach aligns with Li *laoshi*'s statement that all elements in jingju performance should be put at the service of *xi*, theatrical expression. Beyond this general observation, that affects the particularities of each dramatic context and for which there are no specific musical rules, there are other two factors that have a direct influence in jingju melody and which has been studied in detail in state of the art literature, namely the structure of the lyrics, and the linguistic tone of each syllable. Due to the importance of these two elements, I will describe them in detail in the following sections.

Structure

Music structure in jingju, as in all the xiqu genres belonging to the *banqiang bianhua ti*, or system of metric changes, is closely related to the lyrics structure. The system of tune sequences crystalized during the Yuan dynasty, but inherited the music creation principle that was active in poetry—that was meant to be sung—and storytelling during the Tang and Song dynasties. In a nutshell, this principle consists in taking the melody and poetic structure of preexisting poems or songs and arrange new lyrics to fit in that schema. The lyrics are labeled with the title of the original poem or song, so that the performer knows how to sing them. These label gave name to this music form, *qupai*, or 'tune labels.'[8] Each of these tunes has a different form, implying not only a different melody, but also a different number of lines and lines with different number of characters.[9] Therefore, the lyrics structure of this system is known as 长短句 *chang duan ju*, literally 'long and short lines' (Jiang_2 1995: 39). Probably due to the fact that these tunes contain just few lines, a singing passage in the xiqu genres of this system consists in a sequence of such tunes. During the evolution of this system, many sequences became standardized, forming what is usually called 套曲 *taoqu* (Jiang_2 1995: 81), or in the early sources 套数 *taoshu* (Hai 2003: 61), which can be understood as 'tune sets.' This tune set is then the basic lyrics and music structure in the xiqu genres that belong to the system of tune sequences.

The system of metric changes, which appeared several centuries after the system of tune sequences, inherited the same principle of music creation, and in that sense it can be taken as evolved from it. The core of this principle consists in taking a preexisting melodic and poetic structure, writing new lyrics to it, and concatenating several tunes to build a singing passage. Jonathan Stock (1999), introducing the jingju music tradition, links this reutilization of preexisting material lyrics content and even scenic movement, to create what the author calls "stock dramatic structures." According to this author,

> [t]his process [or reusing stock dramatic structures] was assisted by the formulaic nature of traditional song texts; having mastered the basic song structure, the singer needed only substitute new syllables at appropriate points to create a new dramatic scene." (1999: 187)

Consequently, this principle of reusing stock material to create new scenes, which is shared among genres from the two structural systems, might be considered an essential creative element of xiqu in general. The

[8] *Qupai* is an essential concept in Chinese traditional music, determining the melodic structure and performance practice of many genres beyond xiqu. For an overview of the concept and a detailed analysis of its use in instrumental music, please refer to Jones (1989).

[9] With characters I refer to the logograms that form Chinese script, which in this language are called 字 *zi*. It has to be taken into account that each character corresponds to a single syllable. Consequently, that a line has the same number of characters implies that it has the same number of syllables. I will use the term character, since it is the one commonly used in Chinese literature, instead of syllable (音节 *yinjie*).

main and essential difference between the two systems is that in the case of the system of metric changes there is only one single melodic and poetic structure of just two lines. This stanza, as in the case of tune sets, is repeated forming sequences of itself. But differently from the tune sets, its brevity and uniqueness allows its repetition as many times as needed to convey a full dramatic passage.

A second essential difference between the two systems is the mechanism for music expressivity. If in the system of tune sequences each tune or tune set was related to an expressive content, in this new system different expressive contents are achieved by metric variations of the original tune. As a result of these innovations, Su Yi argues that xiqu "strengthened is expressive ability" (2013: 27), since arias can be better adjusted to the dramatic content and adapted to complex expressive contents with more agility. The melody that sets these two lines of lyrics into music is determined by the *shengqiang*, but the lyrics structure is shared by all the genres that belong to the system of metric changes.

The basic lyrics structure of these stanzas consists in two symmetrical lines of seven or ten characters grouped in three sections (respectively, Figures 3 and 4). This structure is considered to be first used in a xiqu genre known as 梆子腔 bangziqiang, qinqiang or 乱弹 luantan, that was formed in the Shaanxi province and whose earliest mention is registered during the rule of 康熙 Kangxi Emperor (1661–1722) from the Qing dynasty (Hai 2003: 148, 151). This is consequently the xiqu genre in which the system of metric changes is first registered. Previously, two important characteristics of the lyrics in this new system has been mentioned, namely the fact the it only uses one type of stanza, and the brevity of this stanza, consisting in only two lines. A third important characteristic is the symmetry of the two lines, that is, both lines count with the same number of characters, and therefore with the same inner structure. Some authors use terms from poetry to name this stanza form, like 对偶 *dui'ou* (Jiang$_2$ 1995: 40) or 联 *lian* (Wichmann 1991: 33), although the most common term in jingju circles, establishing a clear contrast with the *chang duan ju* form, that is, the 'long and short lines' form, is 上下句 *shang xia ju*, literally 'upper and lower lines.' The most common English terminology used for these concepts is couplet for the stanza, opening line for the 'upper line,' *shangju* 上句, and closing line for the 'lower line,' *xiaju* 下句. The

		S1	S2	S3
couplet 1	O	两国	交（哇）锋	龙虎斗，
	C	各为	其主	统貔貅。
couplet 2	O	管待	三（哪）军	要宽厚，
	C	赏罚中	公（呃）平	莫要自由。
couplet 3	O	此一番	领兵	去镇守，
	C	靠山	近水	把营收。
		Liang guo	jiao (wa) feng	long hu dou,
		ge wei	qi zhu	tong pixiu.
		Guan dai	san (na) jun	yao kuanhou,
		shang fa zhong	gong (e) ping	mo yao ziyou.
		Ci yi fan	ling bing	qu zhenshou,
		kao shan	jin shui	ba ying shou.

Figure 3. Examples of seven characters lines.

From Cao (2010/2: 12–14). S stands for line Section, O stands for Opening line, C stands for Closing line.

symmetry of the lines is expressed in their inner structure and number of characters. All authors agree that a standard line consists in either 7 or 10 characters, grouped in three sections of, respectively, 2 + 2 + 3 (Figure 3) or 3 + 3 + 4 (Figure 4) characters. These sections, named 逗 *dou*, consist in "semantic and rhythmic units" (Wichmann 1991: 33). As stated previously, an aria is built by as many couplets as needed to convey the corresponding dramatic content. Within an aria, or aria sections in long ones, all lines carry the same rhyme. All the possible syllabic finals[10] are classified into thirteen rhyme classes known as 辙 *zhe*, and the final syllable of all lines correspond to the same category (Figures 3 and 4), although exceptions my occur in opening lines. The only element that sets opening and closing lines apart is the tonal schema designed for each line.

[10] Chinese linguistics divide the phonological syllable in three parts, an initial part (声母 *shengmu*), consisting in a consonant, a final part (韵母 *yunmu*), consisting in a vocalic nucleus, that can be preceded by a semiconsonant and/or followed by a semivowel, and possible final nasalization, and the tone (字调 *zidiao*) (Yu 2008: 15).

		S1	S2	S3
couplet 1	O	当日里	好风光	忽觉转变，
	C	霎时间	日色淡	似坠西山。
couplet 2	O	在轿中	只觉得	天昏地暗，
	C	耳听得	风声断、雨声喧、 雷声乱、乐声阑珊、 人声呐喊、都道说是	大雨倾天。
couplet 3	O	那花轿	必定是	因陋就简，
	C	隔帘儿	我也曾	侧目偷观。
		Dang ri li	hao fengguang	hu jue zhuanbian,
		sha shijian	ri se dan	shi zhui xi shan.
		Zai jiao zhong	zhi juede	tian hun di an,
		er ting de	feng sheng duan, yu sheng xuan, lei sheng luan, yue sheng lanshan, ren sheng nahan, dou daoshuo shi	da yu qing tian.
		Na huajiao	biding shi	yin lou jiu jian,
		ge lian er	wo ye ceng	ce mu tou guan.

Figure 4. Examples of ten characters lines.

From Liu$_1$ (1992: 320–321). S stands for line Section, O stands for Opening line, C stands for Closing line.

The four tonal categories contained in the linguistic construct used in jingju are classified in two categories, tones 1 and 2 form the 平 *ping* class, and tones 3 and 4 the 仄 *ze* class. Thus, opening lines are expected to end with a *ze* tone class and closing lines with a *ping* tone class. Wichmann (1991: 45) provides a tonal schema for the whole couplet in terms of *ping*-*ze* classes. However, as Zhang$_5$ states, “the *ping*-*ze* classes in jingju couplet lyrics are not as strict as the classical poetry requirements, and only at the line end are they relatively fixed” (1992: 12). This can be observed in the table provided by Pian (1972: 260) with the analysis of *ping*-*ze* tonal classes of 25 jingju couplets, where no clear pattern can be observed, except for the *ping* class ending the closing lines without exceptions, and the *ze* class ending the opening line, with just one exception.

The aforementioned characteristics determine the standard structure of jingju lyrics, but in such a lively tradition as jingju, there are many cases in which this standard structure is modified. The most common alteration affects the number of syllables in a line, which can be augmented (Figure 3, couplet 2, C, S1 and S3, couplet 3, O, S1) or diminished. Arguably, the most common case is the addition of what is called 衬字 *chenzi*, literally 'filling characters.' These can be either words without an essential meaning to the content and that could be omitted without altering much of the message, like pronouns, prepositions, particles, etc., or meaningless syllables, such as /a/, /ja/, /na/, etc., used for prolonging the melodic line of a syllable whose final part is either nasal or a vowel of difficult articulation (Figure 3, couplet 1, O, couplet 2, O and C). A special case of syllable augmentation is the so called 垛字 *duozi*, literally 'piled characters.' This rhetorical device consists on extending the length of a line internally by means of an enumeration of semantic units in groups of three or four characters, as many as needed (Figure 4, couplet 2, C, S2). A usual variation that affects the structure of the couplet is the addition of an extra irregular line, usually few characters that either repeat the last section of the previous line, or interjectional phrases. In very rare occasions, an extra regular line might be added to a couplet. Finally there is a special resource by which the closing line of the last couplet of an aria is replaced with a percussion pattern specifically designed for this function, called 扫头 *saotou* (Mu 2007: 346–359).

Linguistic tones

It is commonly assumed that vocal music with lyrics from tonal languages, that is, languages in which the intonation of a specific speech segments determines its lexical meaning or grammatical function, has to agree in its melody with the linguistic tones to a certain extent in order to ensure understandability and avoid confusion. Being Chinese a tonal language, it is a general assumption that traditional vocal music is directly affected by the linguistic tones. In fact, it is commonly argued that the main difference between xiqu genres lies in the musical features and the dialect in which it is sung. And in fact, these two elements are considered intimately related, as far as it is understood that the phonetic characteristics of a dialect to a certain extent determines the melodic characteristics of its vocal music.

Jingju is not an exception to this assumption, and the influence of linguistic tones for shaping the singing melody is taken for granted. In my first jingju music composition class, Shen Pengfei *laoshi* set the linguistic tones among the first considerations to take into account when arranging a melody for new lyrics. The first preparatory step before start arranging the music is reciting aloud the lyrics, and one of the main goals of this step is to appreciate the tones. In my singing classes with Li Zhengping *laoshi*, the teaching method consisted in letting me memorize his singing, which I had recorded the previous session. If there were some particular problematic passage, he will clarify it by pronouncing the lyrics aloud, emphasizing the tones. In fact, once during my singing, he interrupted me because the way I sang the tone 3 character 爽 *shuǎng* sounded to him as if I were singing the tone 1 character 霜 *shuāng*.

A common expression used in jingju circles to refer to this relationship between tones and melody is 字正腔圆 *zi zheng qiang yuan* (Yu 2008: 9, Zhu 2004: 48, $Zhang_4$ 2011: 45), which literally means "characters should be straight, tune should be round." It can be understood as the goal of achieving intelligibility of the lyrics with a smooth sounding melody. The most important problem to be avoided is precisely the one I caused in my mistaken singing, a so called 倒字 *daozi*, literally "upside-down character," that is, a character that because has been mispronounced is misunderstood or confused with another. In his monograph about the relationship between singing and lyrics, the jingju composer Yu Huiyong argues that both these elements, singing and lyrics, have their own set of rules, and therefore, a successful melody should result from putting the former at the service of the latter without breaking its own rules (2008: 10). The first chapter of that work, which is intended at composers, is precisely devoted to the relationship between singing melody and tones. Yu argues that the rules of both elements usually come into conflict, and therefore the main content of this chapter consists in studying such situations and offer possible solutions. Interestingly, Li *laoshi* refused this argument, stating that in jingju there is no 'conflict' between lyrics and melody whatsoever.

The influence of tones in melody has been largely studied, and most jingju music textbooks include a section devoted to this topic. Xu Zheng has reviewed 90 years of research of this topic in jingju (2007). One of the most remarkable conclusions of this study, as the author argues, is that after almost a century of research, no definite consensus or common agreement has been achieved among the researchers. One of the most important reasons is the very complexity of the linguistic construct used in jingju. I call it construct because the language used in jingju in terms of its phonetic aspect, does not correspond to any existing Chinese dialect, but has been constructed as an addition of elements from different ones, some of them not longer spoken. Most of the authors agree in identifying at least two components, 北京音 *Beijing yin* (BJ), the dialect of Beijing,[11] and 湖广音 *Huguang yin* (HG), the dialect from Huguang (Liu_1 1992, $Zhang_5$ 1992, Zhu 2004, Fei 2005, Yu 2008, Shu 2011, $Zhang_4$ 2011). Even though the definition of which region is meant by Huguang, a term not used currently in China for any administrative division, is not definitely agreed, some authors agree in identifying linguistic characteristics from the Hubei province (Liu_1 1992: 142, Yu 2008: 18). Several sources identify a third component in this construct, the so called 中州韵 *Zhongzhou yun* (ZZ), literally "rhymes from Zhongzhou." Although there is not a definite agreement about its origins, it is generally understood as a standardization of theatrical language in terms of pronunciation according to 周德清 Zhou Deqing's (1277–1365) observations of Northern practices (Liu_1 1992: 141).[12] In terms of linguistic tones, ZZ varied the tonal categories from classical Chinese, consisting in the *ping* 平, *shang* 上, *qu* 去, and *ru* 入 tones, by dividing the first one into *yinping* 阴平 and *yangping* 阳平, and suppressing the *ru* tone, whose characters were dis-

[11] Some English publications (Pian 1972, Wichmann 1991, Stock 1999) use the term Mandarin to refer to BJ. However, this is a rather imprecise term which originally referred to *guanhua* 官话, a group of dialects originated from North China, of which BJ is a part, or to the currently official language of the People's Republic of China, known as *putonghua* 普通话 or standard Chinese, that was based in *guanhua* for its normativization, but not consisting exactly on it. Sara Rovira Esteva, describing standard Chinese, which she acknowledges is commonly known as mandarin, argues that "as a legitimized and institutionalized variety as a supradialectal communication vehicle it [standard Chinese] is not exclusively identified with any geographical variant" (2010: 97).

[12] Zhongzhou is also the ancient name of today's Henan province, so some authors relate *Zhongzhou yun* to the dialect of that province (Wichmann 1991: 204).

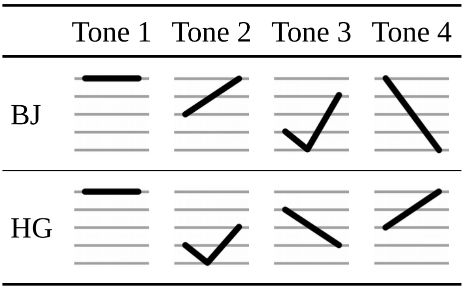

Table 3. BJ and HG tonal contours. Horizontal lines indicate the division in five pitch levels of the speech pitch range.

tributed across the other categories. The resulting categories, *yinping*, *yangping*, *shang* and *qu* tones correspond to the four tonal categories of contemporary Northern dialects of Chinese. In order to ease readability, I will refer to them numerically as tones 1, 2, 3 and 4, according to contemporary usual practice—even thou in jingju circles the ZZ terminology is preferred. Both BJ and HG share the same tone categories with ZZ, in the sense that the same characters that belong to one category in one dialect also belong to the same category in the others. However, the pitch contour with which they are realized in each dialect are different. Henceforth, I will refer to the pitch contour with which each tonal category is realised as tonal contour. Even thou the tonal contours for BJ are universally agreed, since they coincide with contemporary standard Chinese, there is not a definite agreement about the tonal contours for HG. Table 3 shows the most shared assumption of the tonal contours for HG compared by those of BJ.

The resulting combination of these dialects in jingju creates a linguistic construct with a complex phonology. Besides its influence in the tone categories, it also affects to the pronunciation of syllabic initials and finals. In this sense, the pronunciation of standard Chinese, very close to BJ, is taken as reference and deviations from it are specified. Two main concepts are used in jingju circles to refer to such deviations. Firstly the classification of syllables into 尖团字 *jian tuan zi*, what Wichmann translate as "pointed" and "rounded" characters (1991: 186). Although authors give several explanations of these concepts (Wichmann 1991: 186–8, Liu$_1$ 1992: 154–156), the common principle is that *jian*, or "pointed," characters are characterized by some sort of palatalization. So, when studying a new play, jingju actors and actresses should learn which characters that belong to the *tuan*, "rounded," class in standard Chinese should be pronounced as *jian*, "pointed." A second concept is 上口字 *shangkou zi*, literally "up to the mouth" characters, meaning smoothly pronounced characters. These are just a set of specific characters whose pronunciation differs from standard Chinese in a certain way, generally adopting characteristics from Southern dialects.

As a result, the jingju linguistic construct have mainly two systems of tone categories, BJ and HG, two categories of characters, "pointed" or "round," and a set of characters with special pronunciation. What is missing in this construct is a well defined and univocal set of rules that establishes the final pronunciation of each specific character. Consequently, the same character might vary its pronunciation according to factors like the role type, the singing school to which the actor or actress belong, or just his or her own personal preference. The consequence for the study of the relationship between linguistic tones and melody is that the very pitch contour that should be conveyed in the melody is not clearly predefined. Some authors consider that the preferred dialect is HG (Liu_1 1992: 142) or BJ (Pian 1972: 247), while most of them either don't specify a preference or give the jingju music composer the freedom of choosing pronunciation every time to his or her convenience (Yu 2008: 20, $Zhang_4$ 2011: 51). When Shen *laoshi* explained to me the tone categories used in jingju, he wrote down the different pitch contours for BJ and HG, but never specified when a specific character should be considered as realized with one or the other.

If the tonal contour that should be reflected in the melody is not agreed, the way in which this reflection is realised is not agreed either. The majority of authors consider two types of relationship between linguistic tones and melody, although each author gives each relationship type different importance. The first relationship type consists in that the melodic line used to sing a particular syllable resembles in shape the tonal contour of that syllable. The second one consists in the relationship in terms of pitch height between two consecutive syllables, that is, depending of the tonal categories of the involved syllables the pitch height of the melodic line used to sing them should respect a specific principle. Henceforth, I will refer to each relationship type respectively as syllabic contour and pairwise relationship. Regarding the latter, authors don't agree on which point of the melodic line of each syllable should be considered for establishing such relationship. In general terms, it can be observed two approaches. Taking into account that since most authors use examples in musical notation they use to talk in terms of notes, the first approach considers the first note of the melodic line of both syllables to assess this pairwise relationship, while the second considers the last note of the melodic line of the first syllable, and the first note of the following one. The discussion about where to listen for the relationship between tone and melody affects also the syllabic contour. If most authors look at the whole melodic line used for singing a syllable, Wichmann argues that

> the first several pitches of a given melodic-phrase [or melodic line] usually make the speech-tone [tonal contour] of that written-character clear; further pitches sung during a continuation of that syllable need not convey speech-tone and can therefore be sung without denotative restrictions in melodic contour, except that the final pitch of a given melodic phrase must be one that allows the speech-tone of the following written-character to be set clearly relative to it." (1991: 55)

This argument is also shared by $Zhang_4$ (2011: 47) and Yu Huiyong, who, taking Mei Lanfang's own words as example, argues that the tonal information can be conveyed even via a subtle embellishment of the sung melody known as 润腔 *runqiang*, literally 'moist singing' (Yu 2008: 49–50). However, in the example provided by these two authors the melodic contour of the whole syllable is considered. As a result of this situation, and in general terms, three relationship types should be considered, namely syllabic contour, first-first pairwise relationship and last-first pairwise relationship.

The consequence of such a complex situation, with several dialectal systems in play and several approaches for expressing the relationship between linguistic tones and the melody, is, as argued by the aforementioned Xu Zheng, a lack of definite agreement among the authors for the characterisation of the relationship between each particular tone category and the melody. Each author approaches this topic also differently, from giving just few general trends (Wichmann 1991, Zhu 2004, Fei 2005, Yu 2008), while others describe a detailed set of rules and exceptions (Liu_1 1992, $Zhang_4$ 2011), considering the two main relationship types, namely syllabic contour and pairwise relationship, at the same time ($Zhang_4$ 2011), separately (Yu 2008), or differently per each tone category (Liu_1 1992, Fei 2005), or just one of them (Zhu 2004). Undoubtedly, the greater agreement can be found in the analysis of tone 1, which all authors agree to characterize, in terms of pairwise relationship, to be sung in a higher pitch than neighbouring syllables. This agreement can be explained by the fact that its tonal contour in both HG and BJ is located at the highest level of the speech pitch range. Many authors also agree to describe it as having a slightly descending syllabic contour (Yu 2008: 22, $Zhang_4$ 2011: 54). The most common characterization for tone 2 is *di chu*, understood as 低出 "low departure" (Liu_1 1992: 144, Fei 2005: 9) or the homophone 低处 "low location" ($Zhang_4$ 2011: 57), meaning that it usually starts in a lower pitch that the following syllable in terms of pairwise relationship. Many authors also describe a general ascending pitch contour ($Zhang_4$ 2011: 57–8, Yu 2008: 23). However, most authors identify different number of exceptions. Tone 3 is the one for which the widest variety of possible realisations are described. In terms of syllabic contour, it can be realised as ascending, descending (Liu_1 1992: 147, Yu 2008: 29, $Zhang_4$ 2011: 64–65) or even a combination of these two shapes (Fei 2005: 11–2). As for its pairwise relationship, it can be sung either higher or lower than the following syllable (Yu 2008: 35, $Zhang_4$ 2011: 63–64). As for tone 4, different characteristics are offered by different authors. Most of them agree in considering an ascending component in its syllabic contour, either as its predominant shape (Liu_1 1992: 149, Yu 2008: 23), or preceded by a descending movement (Fei 2005: 12), while some authors observe that both ascending and descending syllabic contours are possible ($Zhang_4$ 2011: 68). Regarding pairwise relationship, both higher and lower realisations than following syllables are observed ($Zhang_4$ 2011: 63–64, Zhu 2004: 51). Besides analyzing these four tonal categories, some authors (Liu1 1992: 151–153, Fei 2005: 13–14, $Zhang_4$ 2011: 71–74) also offer some discussion about the traces that former *ru* tones left in jingju, which mostly consists in a staccato or shortened realization of the syllable followed by a rest.

The result of such a complex situation is a lack of precision for the characterisation of each tone category in terms of its relationship with melody, and most authors are conscious about it. Yu (2008) observes that the same melodic contour (腔格 *qiangge* in his terminology) can be used by different tone categories, such as tones 1 and 3 which can use a descending melodic contour (23), and tones 2 and 4 which can use an ascending melody (24); on the other hand, one single tonal category can use different melodic contours, so that tone 2 can be realised with either an ascending or descending melodic contours (30), tone 3 can be sung with either a descending or ascending one (29), and all four tone categories can be realised with a level melodic contour (31). But it is Zhang$_4$ the author who makes the boldest claim, arguing that

> in jingju singing, generally speaking, the only consideration is that when tone 1 is sung together with other tones, it shouldn't be sung lower than tones 2, 3, and 4, and thus there won't be any inverted character [*daozi*] situation. (2011: 87)

As a conclusion, it can be argued that the only common agreement across scholars is that the relationship between tone categories and melody does exist, although they disagree in the specific degree and way, with probably the sole exception of tone one. Consequently, determining the degree in which this relationship is actually realised is important for the goals of this research, since it might be a relevant factor in the actual shape of jingju melodies.

4.3. Role types

An important factor that affects melodic contour in jingju singing is the concept of 行当 *hangdang*, which is commonly translated into English as role type. There is not a standard definition of this concept, which is generally explained by its performing implications and meanings. The *Dictionary of jingju* by Wu$_1$ and Zhou defines it as “the specific acting system of Chinese xiqu” (2007: 1) and then continues with its origins and classification. The way Li Zhengping *laoshi* approached its explanation during our lessons was from the literal meaning of the word. *Hangdang* is a colloquial term for profession, occupation, business. In xiqu it was used to refer to the ‘acting job’ in which an actor or actress was specialized. Due to the amount and complexity of conventions that jingju acting implies for each of the four disciplines that every actor or actress should master, a performer would specialize in the mastering of a specific set of them during his or her acting career. This specific set of conventions is used for the performance of certain type of characters, so that each actor or actress performs this specific type of character during his performing lifetime. From the point of view of the dramatic setting, all the characters of a play should be conceived for being performed through these predefined set of conventions. Consequently, role types are both performative and dramatic categories for characters. Regarding the implications of this categorisation of characters, Bell Yung explains that each role type

> has its own styles of acting, speaking, singing, costume, and make-up. These oral and visual means of expression define the gender, approximate age, social status, profession, and personality of the role type, and thus the identity of the character, in an opera. (1989: 2)

Consequently, each actor or actress, inasmuch as trained in a specific role type, is also specialized in a specific singing style, or set of singing conventions.

The system of role types, meaning the number of role type classes and its subdivisions, varies for each xiqu genre. In jingju there are four broad role type classes, with a complex structure of subclasses. The 生 *sheng* role type is specialized in the performance of male characters. The *dan* role type is used for the performance of female characters. The *jing* is used for portraying male characters with an exaggerated or extreme temperament. Its main characteristic is a complex make-up design that covers the whole face of the performer, using colours and patterns with symbolic meaning about the personality of the character. Because of this defining trait, this role type is commonly known as 花脸 *hualian*, literally 'flowery face,' and usually translated into English as painted face. The fourth class is the 丑 *chou*, used for male or female comic characters, and therefore usually understood as 'clown,' but also used for secondary, generally low class characters. A direct consequence of the role type system is that gender and age of the character is created through the conventionalized performance corresponding to the role type used for portraying it, and therefore has no direct relation with the gender and age of the performer. In 1955 the director 吴祖光 Wu Zuguang filmed several plays performed by Mei Lanfang in the movie 《梅兰芳的舞台艺术》 *Mei Lanfang de wutai yishu* (The scenic art of Mei Lanfang, Beijing, Beijing dianying zhipianchang), including the famous traditional play 《贵妃醉酒》 *Guifei zui jiu* (The concubine gets tipsy), in which the 61 years old actor is able to perform the young and beautiful 杨贵妃 Yang *guifei*, the concubine Yang, without presenting any discomfort to the audience. As mentioned earlier, this is possible because gender and age, and other aspects, are constructed through conventions, and there are specific singing conventions to support this construction.

As previously mentioned, these four role type classes are subdivided into a series of subclasses, for a finer portrayal of character profiles. A description of this complex system is beyond the scope of this thesis. I would point out however two general characteristics. Firstly, there are two important pairs of role type subclasses. On the one hand, the distinction between young and adult characters, for which the prefixes 小 *xiao*, literally ‘small,’ and 老 *lao*, literally ‘old,’ are commonly used. This distinction affects the *sheng* and *dan* classes. On the other hand, a broader distinction between civil and military characters, for which the prefixes 文 *wen* and 武 *wu* are commonly used. This pair affects all four categories. Secondly, for the portrayal of these more specific character profiles, each role type subclass stresses one or some of the four common disciplines. For example, military role types emphasize the discipline of acrobatics, while *chow* should achieve a great mastery of physical acting and declamation.

Regarding the discipline of singing, role types are divided between the so called *shengqiang* 生腔 and *danqiang* 旦腔 (Zhang$_5$ 1992, Jiang$_2$ 1995), literally “singing of the *sheng*” and “singing of the *dan*,” which I will respectively refer to as male singing and female singing. This division implies many factors. The most obvious one affects is timbral features. Role types that use male singing sing with what is known as 大嗓 *dasang*, literally “big throat,” meaning chest voice, while role types that use the female singing sing with 小嗓 *xiaosang*, “small throat,” that is, falsetto. More important for the objectives of this research, is a shift of the pitch range in the female singing to a higher region. This shift implies the use of different cadential notes for each lyrics line (Section 4.4), what is commonly understood as a modal shift (Zhang$_5$ 1992: 31, 445, Jiang$_2$ 1995: 216), with implications in the pitch class organization. Considering the pitch shift between the usual resting notes, Zhang$_5$ argues that female singing is sung a fifth higher than the male singing (1992: 31, 445). Regarding their ambitus, other authors more specifically argue that the female singing in *erhuang* is sung between a fourth and an octave higher, while in *xipi* is sung between a fourth and a fifth higher (Wichmann 1991: 86, Liu$_1$ 1992: 138, “jingju” 1999: 401). Finally, there are some differences in terms of melodic contours, so that female singing is usually "more melismatic" (Wichmann 1991: 88).

If, as their very names imply, they are used to signify the character's gender, they are also used to signify age in some role type subclasses. The *jing* always use the male singing, although with a very distinctive hoarse or nasal timbre, as well as the *chou*, even though, since singing its not his most representative discipline, usually singing a simpler, rougher version of the melody with an also distinctive comic timbre. In the case of the *sheng*, one of his subclasses is devoted to the portrayal of young male characters, the so called *xiaosheng*. In order to express this age, several conventions are adopted, such as the lack of the characteristic artificial beard worn by adult and old male characters, the use of the same white and pink facial make-up as the *dan*, and also the use of the female singing. The *sheng* subclass devoted to the portrayal of adult and old male characters is called *laosheng*. Besides the just mentioned artificial beard and a plain facial make up, it is characterised by the use of male singing. In fact, the *laosheng* is the most representative role type of this singing, and all textbooks start explaining any element of the jingju musical system by giving examples of this role type. In the case of the *dan*, there are two main subclasses for portraying young or adult female characters, namely the 青衣 *qingyi* or 正旦 *zhengdan*, generally used for building females from higher social classes, or with high morale and dignified composure, and the 花旦 *huadan*, used for building young females with a gay and playful character. Besides the same white and pink facial make-up, both role-types are characterised by using female singing, although each of them with their own particularities, being the *qingyi* the most representative role type for female singing. The *dan* subclass used for portraying old females is called *laodan*, and the most notable conventions for expressing her age are the use of a plain facial make-up and of male singing, although with her own characteristics. Consequently, and considering only the role types for which singing is one of their more defining skills, male singing is represented by the singing of the *laosheng*, and it is also used by the *jing* and the *laodan*, while the female singing is represented by the singing of the *qingyi*, and also used by the *huadan* and the *xiaosheng*.

This male-female singing division (生旦分腔 *sheng dan fenqiang*) is an interesting development in xiqu history that was first found with the formation of *xipi* singing. Although there is no final consensus yet about its origins, *xipi*, a term whose first documented mention is registered in 1828 (Hai 2003: 180), is generally understood as evolved from a Western variation of qinqiang, a xiqu genre from Shanxi and Shaanxi provinces (Jiang$_2$ 1995: 205, Hai 2003: 179, Liu$_1$ 1992: 134) with no singing division. Before the appearance of this division, role types in other xiqu genres presented different singing characteristics, mostly in terms of timbre and ornamentation. The main novelty introduced by the male-female singing division in *xipi* is the modal shift that results, according to most scholars and mentioned previously, from the pitch range difference between both singing structures. In xiqu genres without such singing division, male and female characters sing in the same mode, sharing the same resting notes, what might be troublesome in arias sung by both male and female characters, who must sung either in the same pitch range (as it is the case in qinqiang, from which *xipi* evolved) or an octave apart, thus posing important difficulties to one of the two role types involved. The modal shift a fifth (or other interval according to different authors) apart ease the singing for actor or actresses performing male and female characters that share the same aria, since both of them can keep their own pitch range.

According to Hai, singing in qinqiang, and therefore early *xipi* before the singing division, was set to the 徵 *zhi* mode, whose finalis is the fifth degree of the scale. When *xipi* was taken to the Huguang area it entered in contact with a local singing called 襄阳腔 *Xiangyang qiang*, literally, singing from Xiangyang , whose music was set to the 宫 *gong* mode, which rests in the first degree of the scale. Hai argues that the singing in *gong* mode within *xipi*, that is, the male singing, was borrowed from *Xiangyang qiang* (2003: 185-6). Interestingly enough, Wichmann, who does not offer any historical description of the formation of the *shengqiang* in jingju, observes that "[t]he male and female basic melodic contours are more nearly similar in *erhuang* than they are in *xipi*" (1991: 86). This divergence between the male and female singing might be due to the different origins that Hai argues for each of them. This author continues arguing that, if the singing division was originated in *xipi*, once it started to coalesce with *erhuang* in their way to forming the *pihuang* singing (Section 4.4), the latter, which originally did not count with singing division, adopted it because of *xipi*'s influence (Hai 2003: 193). This important development of *pihuang*, the male-female singing division, is given an important value by Jiang$_2$, who considers it a "scientific" achievement, since it allows the natural interaction of female and male characters during singing (Jiang$_2$ 1995: 216).

4.4. *Shengqiang*

What is shengqiang*?*

Shengqiang is the central concept of this research, and arguably the most elusive one. It is one of the many elements that participate in the sung melody performed by an actor or actress, some of them described in this chapter, such as lyrics structure and linguistic tones, role type, and *banshi*, and others much more subtle such as the content of the lyrics, the personality of the character, the dramatic context, the performing school to which the actor of actress belongs, and of course his or her own personal style. Therefore, *shengqiang* is not present at such in the melodic surface, but it is an underlying structure.

As detailed in Chapter 2, most authors do not describe it directly, but via each of the *banshi* through which it is realised. *Shengqiang* is the concept that jingju music scholars use to define what *xipi*, *erhuang*, and such other entities are, and since it is these entities, *xipi*, *erhuang*, and the like, the focus of their interest, and they are taken for granted, they feel no need to define what they are, but to describe their particularities. It is symptomatic that the *Jingju zhishi cidian* (Dictionary of jingju) by Wu$_1$ and Zhou, in the section entitled "Yinyue, shengqiang" (音乐·声腔, Music, *shengqiang*) does not offer an entry for *shengqiang*, probably assuming that the meaning is self evident for the reader as it is the one for music.

However, *shengqiang* is not even a universally established term, and some authors might refer to these entities also with other terms, like 腔调 *qiangdiao* ("jingju" 1999, Liu$_1$ 1992) or 曲调 *qudiao* (Zhang$_5$ 1992). When asked Li Zhengping *laoshi* about *shengqiang*, his first answer was that this, as many other elements of the jingju musical system, is a 模糊概念 *mohu gainiang*, fuzzy concept. He explained this concept from its two lexical components. He divided the jingju singing sonic scope into four elements: 音 *yin*, 声 *sheng*, 腔 *qiang*, 乐 *yue*. The first two words mean 'sound' in contemporary standard Chinese, with a nuance towards 'voice,' 'vocal sound' in the second. In fact, the word 声音 *shengyin* in standard Chinese means either 'sound' or 'voice.' The fourth word, *yue*, means 'music,' usually combined with *yin*, 音乐 *yinyue*. It is the third term the most problematic one. Its original meaning refers to cavities inside an animal or human body, but more specifically to the thoracic cavity, and probably by extension, it is also used to refer to vocal utterances, either spoken or specially sung ones. Therefore it is commonly used to refer to an entity of vocal melody, carrying a specific articulation, a stylistic identity, and necessarily a formal structure, even though it is commonly translated as 'tune.' Wichmann coined the term "melodic-phrase" to refer to *qiang*, and quoting his teacher Wu Junda, she defines it as "'the joining of written-character and song'" (1991: 54), that is, the singing of a syllable. Back to Li *laoshi*'s explanation of *shengqiang*, he related each of those four elements with four musical dimensions. *Yin* refers to timbre, vocal quality, *sheng* refers to pitch, both ambitus and tuning, *qiang* refers to the singing technique, and *yue* to the instrumental accompaniment. Consequently, for him *shengqiang* refers to the pitch content and the technique (or style) of singing.

In the introduction to her monograph *Zhongguo xiqu yinyue* (Chinese xiqu music), Jiang$_2$ Jing offers an interesting discussion on jingju music terminology. The author argues that originally *shengqiang* was used to name the singing of a xiqu genre by referring to its geographical origin—in fact, most *shengqiang* names are toponyms or related words. Used in this way, *shengqiang* is, according to Jiang$_2$, equivalent to xiqu genre (*juzhong*) (1995: 34), since many of them only use one *shengqiang*. However, the author also attempts a definition of *shengqiang* according to its current use.

> Nowadays, the term *shengqiang* from xiqu music roughly indicates a general designation for the origin, vocal (and instrumental) performance practice, accompanying instruments, principles of musical structure, musical style and other aspects of the characteristics to a certain singing [唱腔 *changqiang*]. Broadly speaking, it is also closely related to aspects like the libretto format, traditional repertoire, and acting characteristics.(1995: 35)

Cao Baorong gives a definition in very similar terms. The author argues that "*sheng*- from jingju *shengqiang* is the singing voice [演唱之声 *yanchang zhi sheng*], -*qiang* is the tune [*qiangdiao*] that gives form to the melody, '*shengqiang*' is then singing [*changqiang*]" (Cao 2010/1: 1). The problem with these definitions is that they transfers the problem to the concept of *changqiang*, which is semantically very close to *shengqiang*. In fact, both have *qiang* as main lexeme, and in this case *sheng* ('voice, sound') is substituted by *chang*, 'to sing,' forming a term that in jingju circles is commonly used to refer to vocal melody as opposed to the instrumental component. However, $Jiang_2$'s is the most explicit attempt to come with a definition of *shengqiang*.

In non Chinese sources different terms have been used to translate *shengqiang*, indicating different understanding of the concept by the authors. Both Schönfelder (1972: 9) and Stock (1999: 193) have understood *shengqiang* respectively as "Musizierstil" and "melodic style," although the latter author had previously understood *shengqiang* as "melodic outline" (Stock 1993: 233), what indicates the difficulty of grasping this concept with English terminology. This translation is closer to Pian's understanding. Although this author does not explicitly mention *shengqiang*, it is obvious that she is referring to it when she explains that "there are in the Peking Opera two major categories of melodies, the *Shipyi* and the *Ellhwang*"[13] (1972: 240, italics from the original). From this quote it can be observed that Pian understands *shengqiang* as a "category of melodies." The author continues stating that she "shall not define these terms [*Shipyi* and *Ellhwang*] beyond saying that each is a generic name for a particular list of melodies" (240). Consequently, for Pian, *shengqiang* is that what gives unity to a certain "category" or "list" of melodies. The function of this unifying melodic entity is made explicit when the author argues that

> the musical composition in the Peking Opera consists essentially of a limited number of melodies, which are not only repeated and manipulated within a single opera, but are also capable of serving as material in any number of operas. (237)

[13] Pian uses the Chinese romanization system conceived by her father, the linguis 赵元任 Yuen Ren Chao called Gwoyeu Romatzyh.

This statement can be also understood as a definition of *shengqiang* as the limited melodic stock from which all music in jingju is arranged. The transformations that this melodic material experiences in the arrangement process and which results in the extensive melodic variety perceived by the listener is considered by Pian when acknowledges that "the existence of variant forms can be reconciled with the notion that the same melodic material is virtually being repeated from stanza to stanza" (242). This statement, which the author uses as the goal of her paper, furthermore specifies that it is the "stanza," that is, the couplet, the melodic unit that is "repeated" and "varied."

In his detailed analysis of music in Cantonese yueju, a xiqu genre that, like jingju, also belongs to the *pihuang* system, Bell Yung, without explicitly mentioning it, defines *shengqiang* as "tune family" (1989: 62). The author explains this concept in the following way:

> Through repeated use in different plays over an extended period of time and through many generations of performance and transmission, a tune in a particular regional opera undergoes drastic and lasting changes in different aspects, most often in metrical and rhythmic structures. A single tune develops into two or more versions, each of which in time sufficiently differentiates itself from the others so as to establish its own identity, name, and dramatic function. Although these tunes share certain tonal, modal and large structural features, they tend to differ from each other in metrical, rhythmic, and melodic details. Such tunes can best be described as forming a "tune family," a term which not only indicates the shared features, but also points to the fact that the tunes have developed from a single tune through the passage of time. (62)

The author continues stating that *xipi* and *erhuang* are "the two families of tunes which form the core of musical material in Peking opera" (62–63), as is the case of 梆子 *bongji* and 二王 *yiwong* for Cantonese yueju, two tune families which respectively share origins with the jingju ones. Consequently, it is manifest that Yung is referring to *shengqiang* as tune family. This term, as its explanation shows, stresses the conception of *shengqiang* as a melodic root, since it is conceived as an original tune, from which all existing tune variations have evolved. These tunes that form the family, and which in Cantonese yueju are known as *bongwong*, differentiate from each other in terms of "metrical, rhythmic, and melodic details," a description which resembles the concept of *banshi*. It is interesting to notice that, once the original tune evolved into these variations, its remaining traits as shared by those are "certain tonal, modal and large structural features," elements which coincide with most jingju textbook descriptions. This concept of tune family has been also used by other scholars, like Jonathan Stock (2003: 32–33, 2006: 278) and Nancy Guy (2005: 171) for explaining what *shengqiang* is, but without mentioning a Chinese original term.

On the other hand, Elizabeth Wichmann's understanding of this entity differs from the concept of tune family. Firstly, it must be noted that the author, who constantly refers to Chinese original terminology, does not use the term *shengqiang* as such. Even though she uses the term *shengqiang xitong*, which she translates as modal system—pointing out that its literal translation is "'vocal melodic-passage system'"—(1991: 53), when referring to *xipi* and *erhuang* Wichmann uses the term mode (71), for which the terms 调式 *diaoshi* and *qiangdiao* are given—but not *shengqiang*. In this work, the author uses the term *shengqiang xitong*, modal system, to refer to a group of related *shengqiang*, or modes according to her terminology, so that "[t]he *xipi* modal system takes its name from its principal mode, *xipi*; *erhuang* is the principal mode of the *erhuang* system" (71). In the description provided for mode, Wichmann argues that "[e]ach is identified by its unique, characteristic patterns of modal rhythm, song structure, melodic contour and construction, and keys and cadences" (72). As it is ostensible from this description, a melodic contour is included, and even a so called "basic melodic contour" is offered for *xipi* and *erhuang* in male singing (80), which is then compared with sample melodies from actual arias in other *banshi* and the female singing. The author even identify *xipi* and *erhuang* with "characteristic pitch progressions."[14] However, no information about the origin of these basic melodic contours and characteristic pitch progressions—that is, if they are the result of the author's analysis or they were learnt from her teachers as a common knowledge in jingju circles—,no analysis of how the basic melodic contour is transformed into each of the sample melodies, or how the characteristic pitch progressions build the melody is provided. More interestingly, after

[14] These progressions are given in *jianpu* notation, so that for *xipi* they are "1 2 3 and 3 2 1," and for *erhuang* "2 3 2 and 1 2 1." The numbers can be understood as the scale degrees.

presenting these basic melodic contours aligned with examples from actual arias, the author concludes that

> [w]ithin the patterns provided by the basic melodic contour and the type of melodic construction of each mode, there is a great deal of flexibility. These patterns are by no means “set melodies”; they are rather modal melodic tendencies. (82-3)

This claim reduces the tune value of *shengqiang*, thus drifting her understanding apart from the concept of tune family.

Wichmann uses the term *shengqiang xitong* with a second meaning, “musical system,” in this case to refer to *pihuang* (1991: 53). This is the meaning with which *shengqiang xitong* is usually used in Chinese sources. $Jiang_2$ Jing argues that this term started to be used in the 50s to refer to the group of *shengqiang* from different xiqu genres that evolved historically from a common origin (1995: 35–36), and therefore it can be understood as *shengqiang* system. It has to be noted that one xiqu genre may use more than one *shengqiang*, and therefore one single genre can belong to different *shengqiang* systems. This criterion has been used as a different method for classifying xiqu genres from the one that divides them into the system of tune sequences and the system of metric changes. This new criterion establishes what is known as the 四大声腔 *si da shengqiang*, the ‘four great *shengqiang*,’ where *shengqiang* is a short form for *shengqiang* system. This four *shengqiang* systems are 昆腔 *kunqiang*, 高腔 *gaoqiang*, *bangziqiang* and 皮黄腔 *pihuangqiang* ($Jiang_2$ 1995: 36, Huang 204, Zhou 117, Yuan 212).[15] The name of all these *shengqiang* systems ends with the lexeme *qiang*, whose meaning has been discussed previously. In order to ease readability and make a more precise use of the term, henceforth I will refer to them as respectively *kun* system, *gao* system, *bangzi* system and *pihuang* system. The first two, originated in the Ming dynasty, belong to the system of tune sequences and are mostly

[15] The phrase “four great *shengqiang*” is also applied to the four *shengqiang*, in this case not understood as *shengqiang* system, that were the most important ones during the Ming dynasty, namely 昆山腔 *kunshanqiang*, 弋阳腔 *yiyangqiang*, 余姚腔 *yuyaoqiang* and 海盐腔 *haiyanqiang*. Of these four, the first two are still performed today, evolved respectively into the nowadays *kunqiang* and *gaoqiang*. To differentiate them from the current “four great *shengqiang*” they are known as 明代四大声腔 *Ming dai si da shengqiang*, ‘the four great *shengqiang* from the Ming dynast’ (Zhou 2003: 117), or 老四大声腔 *lao si da shengqiang*, ‘old four great *shengqiang*’ (Yuan 2010: 2010).

spread through Southern China, while the last two, originated in the Qing dynasty, belong to the system of metric changes, and even though they found a national diffusion, they are mostly associated with Northern genres. Kunju is the genre where *kun* system was born and the only one that uses it exclusively, although divided into Northern and Southern styles. The most representatives genres that use *gao* system are chuanju from Sichuan, 湘剧 xiangju and 祁剧 qiju from Hunan, 赣剧 ganju from Jiangxi, 桂剧 guiju from Guangxi, and 婺剧 wuju from Zhejiang. *Bangzi* system found a very wide diffusion across the whole country, and gave birth to tens of genres, of which the ones that found a bigger impact nationwide are qinqiang from Shaanxi, jinju and 蒲州梆子 Puzhou bangzi from Shanxi, Henan bangzi, nowadays known as yuju, and Hebei bangzi.

Among the "four great *shengqiang*," *pihuang* system is the only one that is formed by the combination of two individual *shengqiang*, namely *xipi* and *erhuang*. In fact, the term *pihuang* results from the combination of the second syllable of its two component *shengqiang*. This combination does not mean that the two fused with each other into a single form, but they became considered as a unity since they were commonly performed together, even for a single play (Hai 2003: 179). The temporal and geographical origin of each *shengqiang* and of its combination into a performing unity are not clear. Although it is beyond the scope of this thesis to offer a discussion about the different theories, I would just point out to some facts that might be relevant for the present research.

The origin of *xipi* is the one that has found a major consensus among scholars, who consider it as the form into which the genre qinqiang, originated in the Shaanxi and Shanxi area, evolved once it arrived to the Huguang region during the Kangxi emperor reign (1661–1722),[16] where it adopted the HG dialect and, as mentioned previously, borrowed the male singing from *Xiangyang qiang*. The origin of *erhuang* is still disputed, and different number of theories is given by the scholars (Liu$_1$ 1992: 133–134, Jiang$_2$ 1995: 205–206, Yuan 2000: 249–250, Zhou 2003: 155, Huang

[16] A common argument for establishing this origin is the name of the *shengqiang* itself, in which the lexeme *xi* means "Western", which from the Huguang region's point of view usually referred to the Shaanxi and Shanxi area, and the lexeme *pi* is a dialectal term to refer to "tune" (Jiang$_2$ 1995: 205, Hai 2003: 180–181).

2006: 276–277). According to the xiqu music historian Hai Zhen, the first documentary register of the term *erhuang* is dated in 1784 (2003: 186–187), and most scholars consider that it was formed as an individual *shengqiang* by then. About the place of origin, the dispute is wider. Hai argues that among the different theories proposed, three provinces are the most probable ones for the origin of *erhuang*, namely Hubei, Anhui and Jiangxi, of which he believes the first one is the most probable place of origin.[17]

If the formation of both *xipi* and *erhuang* is unclear, the moment and place were they become an inseparable pair is even more unclear. According to Colin P. Mackerras, when *erhuang* arrived to Beijing at the end of the 18th century from the South, it already included the performance of *xipi* (1972: 127). Considering the locations proposed by scholars for the birth of both *shengqiang*, it is plausible that they started to be conjointly performed in Hubei or neighboring areas before the last decade of the 18th century. This location would explain the diffusion of *pihuang* system throughout the country. To the North it reached Beijing, where, as already mentioned, gave birth to jingju, and to the South it reached Guangdong, forming Cantonese yueju, while in its original Hubei evolved into 汉剧 hanju. As it was reaching different regions it was incorporated to local xiqu genres such as 徽剧 huiju in Hubei, chuanju in Sichuan, ganju in Jiangxi, 滇剧 dianju in Yunnan, qiju in Hunan, etc. ($Jiang_2$ 2005: 206–207, Huang 2006: 278).

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[17] A source of dispute about the origin of *erhuang* comes from the very meaning of the term itself, for which several theories have been proposed. One of the most common one argues that, since the first lexeme, *er*, means "two", it might refer to two counties in the Hubei province whose name start with *Huang*, namely 黄陂 Huangpi and 黄冈 Huanggang. Other theory argues that since the first character, 二, can be pronounce as *yi* in Southern dialects, it is a mistaken writing of the homophone 宜, so that it would refer to the 宜黄 Yihuang county in Jiangxi. Yet another theories take into account the fact that some documents write the second syllable with the character 簧 instead of the homophone 黄. Since the former means "reed," this theory argues that it refers to the accompaniment instrument. Hai zhen (2003) argues that this term used to have the meaning of "sounding, vibrating body," including string (188). Therefore, he concludes that *erhuang*, at the time of its first documentary register, was a general term for the genres whose main accompaniment instrument belongs to the 胡琴 huqin family (189). The author concludes that it will not acquire its actual meaning as a *shengqiang* from the system of metric changes until the reign of Jiaqing emperor (1796–1820) (189–190). The author himself acknowledges that his theory is contrary to the opinion of most scholars.

Finally, at the end of the 19th century and beginning of the 20th century, many regional genres of song, dance and storytelling experienced a process of theatralisation,[18] resulting in the formation of a great number of what is usually known as *difang xi*, literally “local plays,” which I will refer to as regional (xiqu) genres. These young genres are not classified according to the systems of tune sequences and metric patterns, nor the ‘four great *shengqiang*.’ As an evolution from regional music, they are characterized by a simpler and more straightforward style than older genres, although some of them developed rather complex musical systems, influenced by the well established previous genres. Among the regional genres that achieved a wider impact, there are Shaoxing yueju, pingju from Hebei, huju from Shanghai, huangmeixi from Anhui, etc.[19]

***Jingju* shengqiang**

Even though it evolved from the *pihuang* genre that reached Beijing from Southern provinces, jingju is characterized as a 多声腔剧种 *duo shengqiang juzhong*, a multi-*shengqiang* xiqu genre (Jiang$_2$ 1995: 215). The coexistence of different *shengqiang* in this genre is due to both internal and external historical reasons. Beyond the mere fact that *pihuang* already consists in the combination of two *shengqiang*, it developed two derived ones from each of them by applying a method known as 反调 *fandiao*, literally ‘inverse mode,’ a development that, as in the case of the singing division, is first produced in the *pihuang* system (Hai 2003: 192). The inverse mode results from shifting the 正调 *zhengdiao*, literally ‘straight mode,’ which is the original one, one step in the cycle of fifths, a practice that is common in Chinese traditional instrumental music, where

[18] For a description of the evolution of some of these genres and their process of theatralization refer to Stock’s work on huju (2003), Jiang$_1$’s work on Shaoxing yueju (2009) and my master thesis on pingju (Caro 2012).

[19] The description offered in this paragraphs about the classification of xiqu genres is restricted to the Han ethnic majority. However, many ethnic minorities in China have developed historical traditions, such as the Zhuang, the Bai, the Dong, the Mongols, the Uyghurs, the Manchus, the Koreans, etc. (Jiang$_2$ 1995: 333, Huang 2006: 311) One of the most developed ones is the Tibetan ache lhamo (known as *zangxi* 藏戏 in Chinese), whose formation are dated in the 15th century. During their history, these traditions have received the influence of Han xiqu, and adopted many of its conventions. However, their consideration of xiqu depends on a thorough analysis in terms of how they adhere to the principles of xiqu.

this step can be taken either upwards or downwards in that cycle (Jones 1998: 115–116). In jingju though, the shift is understood a fourth downwards. The result of this practice is two new *shengqiang*, identified by the lexeme *fan-* appended before the name of the original ones, namely *fan'erhuang* and *fanxipi*.[20]

Regarding the external reasons, it has to be considered the historical context in which jingju was formed. A commonplace for the birth of jingju is to link it to the arrival of 徽班 *huiban*, Anhui troupes, to Beijing to celebrate the 80th birthday of emperor Qianlong. The Beijing that these troupes found was, as described by Mackerras, "a true meeting-place for various styles from all over China" (1972: 106), since actors from all over the country brought their regional genres to the capital. The city also saw the development of at that time novel scene of public xiqu playhouses, "with permanent stages and arrangements for seating spectators" (Mackerras 1972: 110). As a result of this xiqu market, each troupe would compete with the others to attract the larger audience, by offering the most appealing performance. The Anhui troupes were the ones to have first performed *pihuang* singing in the capital, but they soon started incorporating actors from other genres present in the capital, specially qinqiang, but also 京腔 jingqiang and kunju. Few decades after their arrival, Anhui companies dominated the xiqu scene in Beijing, especially four of them that became to be known as the 四大徽班 *si da huiban*, the 'four great Anhui troupes.' These companies, where performers from different genres came together to share a stage, formed the framework in which jingju was born.[21] This context would characterise jingju music as a combination of different xiqu genres, which implies different *shengqiang*, around a core of *pihuang*

[20] The relationship between these two inverse modes with their respective original modes is different in each case. *Fan'erhuang*, which is the most commonly used (Hai 203: 195) is generally understood as a shift a fourth downwards of *erhuang*'s first degree, therefore maintaining the same modal implications and cadential notes with respect this new first degree ($Zhang_5$ 1992: 305, $Jiang_2$ 1995: 237). In the case of *fanxipi*, which appeared later ("jingju" 1999: 448) and is much limited in use ($Zhang_5$ 1992: 873), the first degree is maintained in the same pitch as the one of *xipi*, but the cadential notes change, therefore provoking a modal shift (Liu_1 1992: 421, $Zhang_5$ 1992: 872, $Jiang_2$ 1995: 258, "jingju" 1999: 420). These explanations are based in the male singing.

[21] It is beyond the scope to offer a description of jingju history, a matter that has been well studied. Of relevance are the works by Mackerras (1972, 1988), the extensive work edited by Ma Shaobo et al. (1999) and the more concise and personal study by Su Yi (2013).

singing, and this genre as a malleable one, capable of incorporating the musical stocks that the performers might need.

Considering the whole repertoire of jingju plays, and taking *xipi* and *erhuang* as the core ones, the number of *shengqiang* for this genre slightly varies among scholars. In the literature consulted for this research, there is an agreement on considering the following eight *shengqiang*: *xipi*, *fanxipi*, *erhuang*, *fan'erhuang*, *sipingdiao*, *nanbangzi*, *gaobozi* and *chuiqiang* (Schönfelder 1972, Wichmann 1991, Liu_1 1992, Zhang_5 1992, 2006, Jiang_2 1995, “jingju” 1999). Most authors also consider an inverse *shengqiang* created from *sipingdiao*, *fansipingdiao* 反四平调, and also include *kunqiang* among the jingju *shengqiang* (Liu_1 1992, Zhang_5 2006, Jiang_2 1995, “jingju” 1999). Some scholars group some of these *shengqiang* in sets related either to *xipi* or *erhuang*. This is the meaning that Wichmann (1991) gives to the term modal system. According to the author, the *xipi* modal system is formed by *xipi*, *fanxipi*, *nanbangzi*, and *chuiqiang*. The *erhuang* modal system is formed by *erhuang*, *fan'erhuang*, *sipingdiao*, and *gaobozi*. “Jingju” (1999) group some *shengqiang* into 腔系 *qiangxi*, a term that can be understood as a short form for *shengqiang xitong*, *shengqiang* system. The one for *xipi* also includes *fanxipi* and *nanbangzi*. The one for *erhuang* includes *fan'erhuang*, and two *shengqiang* only mentioned in that publication, namely 汉调 *handiao* and 徽调 *huidiao*. Finally, some authors also consider a category that might not consist in a *shengqiang*, called *za qiang xiao diao*, literally ‘varied tunes and small songs’ (Jiang_2 1995: 216) or 杂调 *zadiao*, literally ‘varied songs’ (“jingju” 1999: 464). This is a broad category to include all the folk songs or tunes from storytelling genres that are also used in jingju, a feature that makes explicit the flexibility of this genre for incorporating new music. Since the focus of this research are *erhuang* and *xipi*, I will detail in the remainder of this section how these two *shengqiang* are described in the literature.

As mentioned previously, the basic structural unit for lyrics in jingju arias is the couplet. This unit is used as a module that can be repeated as many times as needed to convey the required content. Consequently, *erhuang* and *xipi* offer a set of conventions to set this unit into music. Of course, this conventions are used creatively with a certain degree of freedom according to the needs of the performers. Most of these variations are explained either by the influence of linguistic tones, or more importantly by the needs of the dramatic, expressive, emotional content of the aria. Jonathan Stock has analysed jingju arias composed of two couplets arranged for the same role type (actually the same singer), *shengqiang* and *banshi*, and has come to the conclusion that they were "conceived as a four-line musical structure rather than being a pair of incidentally adjacent couplets" (1999: 199). Indeed, in my classes with Shen *laoshi*, he explained that exact repetitions should be avoided, and changes should be made just for the sake of variety and avoiding monotony, an argument also maintained by Liu_1 Jidian (1992: 165). Consequently, it seems that there exists a structural conceptualization that goes beyond the couplet. $Zhang_3$ Yunqing argues that music conventions of jingju *shengqiang* are "both strict and free," and quoting a personal communication from Liu_1 Jidian maintains that "the tunes [*qiangdiao*] of jingju *xipi* and *erhuang* are 'fixed forms that not stress the tune'" (2011: 1). Notwithstanding this, as Pian argues, "the existence of variant forms can be reconciled with the notion that the same melodic material is virtually being repeated from stanza to stanza" (1972: 242). Consequently, even though many sorts of factors influence the final melody of a particular aria, it is the melodic conventions related to the couplet the ones that build the underlying melodic framework that is afterwards altered.

If one of the characteristics of jingju couplets is their symmetry, their melodic rendition is not necessarily so in terms of the metric distribution of each line lyrics. Wichmann calls this element 'song structure' (1991: 74), and it is an important factor that differentiates *erhuang* and *xipi*. This rhythmic structure implies two elements, the standard number of measures[22] for singing each line and each of their sections, and the metrical position of each of the 7 or 10 characters of a lyrics line within the rhythmic span of a melodic line (Figure 5). According to these two criteria, the rhythmic structure of the melodic lines in a couplet can keep symmetry

[22] Traditionally, rhythm in jingju music is organized according to two basic elements, *ban*, which literally refers to the wooden clappers used to mark stressed beats, and extensively refers also to the stressed beat itself, and *yan*, literally meaning 'eye,' and used to refer to the unstressed beats. When jingju music is notated, the *ban* is considered as the first beat of a measure, and the number of *yan* between two *ban* is used to determine the metre. Therefore, the use of the concept 小节 *xiaojie*, measure, is already standardized in jingju theoretical literature.

Erhuang
Op. l.: X X |x - |(1) |X X |x - |- - |(3) |X x |0 X |X 0 |
Cl. l.: XxX |0XxX|X x |0 X |X 0 |

Xipi
Op. l.: 0 XX|-x 0|XxX |(1) |X x |0 X |X 0 |
Cl. l.: 0 XX|-x 0|XxX |(1) |X x |0 X |X 0 |

Figure 5. Metric schemata for *erhuang* and *xipi*.
Based on Zhang$_5$ (1992). Uppercase X stand for positions shared by 7 and 10 characters lines. Lowercase x stand for positions only in 10 characters lines (in 7 character lines, these positions will be covered by extending the previous character). Underscore indicates quaver, otherwise, crotchet. Hyphen indicates prolongation of the previous character. 0 stands for rest. Numbers in brackets indicate number of measures of instrumental interlude.

between them or not. In the case of *xipi*, the standard rhythmic structure of the opening and closing lines is identical, and therefore symmetrical. Zhang$_5$ (1992: 13) describes this structure as parallel (平行 *pingxing*), while the term used by Wichmann (1991: 74) to refer to this structure interestingly is “changed-tail-structure” (换尾式 *huanweishi*), which vividly explains that both lines are identical except for the cadential melodic inflection (rhythmically, the two lines are completely identical in their standard form), which sets apart the opening line from the closing line, and marks the progression of the couplets.

Contrastingly, *erhuang*’s most representative rhythmic structure is asymmetric, although it also uses a symmetric one. In the asymmetric structure, the third section of the opening line is separated from the second one by a proportionally long instrumental interlude, while in the closing line the first two sections are compressed into two measures and the third one, whose own structure is the same as the third section of the opening line, is sung directly after the second one without any pause. This asymmetric structure is described by Zhang$_5$ (1992: 13) as contrasting (对比 *duibi*), and Wichmann (1991: 74) refers to it as “extended-pattern-structure” (延伸型 *yanshenxing*). This structure, as the most representative one for *erhuang*, is the preferred one for the beginning or the end of an aria or an aria section, so that the *erhuang* identity is well established. But after some couplets are sung in this structure, it is common to change to a symmetric one. This structure consists in that the opening line takes the same rhythmic structure of the closing line. This form is more agile, and it is commonly used to advance the action and convey a more narrative character, for which reason Zhang$_5$ names this structure 联句形式 *lian ju xingshi*, form of connected lines. Consequently, *erhuang* has two types of opening line, the one from the asymmetric structure, named by Jiang$_2$ (1995: 218) “long opening line” (长上句 *chang shangju*), and the one from the symmetric structure, named by Zhang$_5$ (1992: 9, 42) “reduced line” (紧缩句 *jinsuo ju*) and by Jiang$_2$ (1995: 219) “tight opening line” (紧上句 *jin shangju*). Jiang$_2$ (1995: 221–222) and Zhang$_5$ (1992: 70–71) consider also a “concluding line” (named respectively 落板句 *laoban ju* and *jieshu ju*) in *erhuang*, consisting on a melodic prolongation of the second section of the closing line, which is used as the last line of an aria. Zhang$_5$ argues that *xipi* also uses a concluding line, consisting just in a melodic pattern for the last two syllables (1992: 474). This author defines even one more line type, which he calls turning line (*zhuanju*), consisting in the opening line just before a concluding line being characterised with a specific melodic pattern.

Besides these standard forms, the rhythmic structure of any *shengqiang* might be varied mostly by two factors. The first is an irregular number of lyrics, as previously described in Section 4.2. Filling characters do not create much variation, since they are inserted in the rhythmic (and melodic) structure, or, in the case they occur at the beginning of a line or a section, they are added as a sort of anacrusis. More important deviations to the standard structure are produced by the aforementioned *duozi* or piled characters. These sequences, usually structured into syntagmatic or syntactic units, are rendered in singing through a specific rhythmic convention, which implies a new, more agile tempo and metre, usually understood as a specific *banshi*, known as 垛板 *duoban* (Section 4.5). According to Shen *laoshi*’s explanations, this rhythmic convention occurs as a substitution or prolongation of the second section of the line, so that the one that is affected starts with the usual melodic figure that characterizes the first section, and concludes with the one that defines the third one, to signal the end of the line (Figure 4, couplet 2, C). The second factor that varies the standard form consists in melodic extensions, *tuoqiang*. They usually occur as a melismatic prolongation of the last syllable of a line section, although they might occasionally appear in inner ones, in these cases usually as a sustained, long pitch. The melismatic prolongations of final syllables, especially those of the last syllable of a line, are themselves melodic conventions, and are commonly known as *tuoqiang*, literally ‘dragged singing.’

Finally, regarding the metrical position of the syllables, most authors offer metrical schemata (Figure 5) with these positions as the *shengqiang* is realized in the *banshi* known as *yuanban*, which, as it will be detailed in the following section, is considered to convey the original form of the tune that formed the *shengqiang*. However, these schemata experience many variations, and are practically unrecognizable in fast *banshi*. The only common general description of syllabic position that is not directly related to any *banshi* is the metrical position of the first and last syllables of the couplets lines. This is usually expressed in an almost fixed phrase. *Erhuang* lines are described as 板起板落 *ban qi ban lao*, that is, starting on *ban*, and resting on *ban*, where *ban* should be understood as accented beat (Wichmann 1991: 72, Liu_1 1992: 166, $Zhang_5$ 1992: 31, “jingju” 1999: 401, Wu_1 2007: 16). Contrastingly, *xipi* lines are described as 眼起板落 *yan qi ban lao*, starting on *yan*, or unaccented beat, and resting on *ban* (Wichmann 1991: 72, $Zhang_5$ 1992: 445, “jingju” 1999: 431). These characteristics are rather consistently maintained across *banshi* and other different kinds of variations.

Regarding the rhythmic aspect of these two *shengqiang*, scholars also agree in describing the general rhythmic character of *erhuang* and *xipi*. There is specifically one single adjective for each of them that is constantly repeated, so that *erhuang* is described as 平稳 *pingwen*, “smooth and steady” (Liu_1 1992: 166, $Zhang_5$ 1992: 31, “jingju” 1999: 401, Wu_1 2007: 16, Cao 2010/1: 2), whilst *xipi* is characterized as 活泼 *huopo*, “lively” (Liu_1 1992: 318, $Zhang_5$ 1992: 445, Wu_1 2007: 18, Cao 2010/2: 1).

Regarding the melodic description of *erhuang* and *xipi*, there is a wider variety depending on the definition of *shengqiang* that each author is using. As described previously, most of the definitions consider the idea of an original tune, and indeed most of the authors intend to describe each *shengqiang*'s melodic identity through a given tune, but in almost all cases it consists in a couplet of an actual aria for *laosheng* in *yuanban*, the *banshi* that is thought to be the closest to the original form. Consequently, in this real example there may be many other factors not related to *shengqiang* that are intervening in the actual contour of the given tune. As it has already been argued, *shengqiang* is an underlying structure, and by giving a melodic surface, what is intrinsic to the *shengqiang* remains unrevealed. In fact, new couplets from actual arias are given to illustrate a different combination of role type or *banshi*. As a consequence, this examples fail in describing what is the melodic identity of each *shengqiang*. Only Wichmann, among the sources consulted for this research, attempts at giving a "basic melodic contour" detached from any *banshi* (1991: 80, 87), but even in this case, the author gives different contours for male and female singing, and each of them are notated using the metrical conventions for transcribing *yuanban*. Notwithstanding this, she also points out "characteristic pitch progressions" for *erhuang* and *xipi* (1991: 79), but no further analysis is provided about how this progressions build the melodic contour. Zhang3 Yunqing's concept of "nuclear notes" (*hexin yin*) can be understood as an extension of Wichmann's characteristic pitch progressions, and as in her case, Zhang3 do not offer a development of the concept either.

Most authors though agree in giving a more common general characterization of *erhuang* and *xipi* in terms of their melodic progression (旋律进行 *xuanlü jinxing*), or, according to Wichmann's terminology, "melodic construction" (1991: 79). *Erhuang* is thus characterized by a predominant use of conjunct steps (级进 *jijin*) (Wichmann 1991: 79, Zhang5 1992: 31, Cao 2010/1: 2), whilst *xipi* is characterized by a more frequent use of leaps (跳进 *tiaojin*) (Wichmann 1991: 79, Zhang5 1992: 445, "jingju" 1999: 431). These melodic characterization is usually related to the rhythmic one, and the stepwise progression in *erhuang* is connected to its steady character, and the more frequent use of leaps in *xipi* is related to its lively quality. In fact, another common adjective for describing *xipi* is 跳

跃 *tiaoyue*, literally “bouncing” (Liu$_1$ 1992: 318, Wu$_1$ 2007: 18, Cao 2010/2: 1).

An important characteristic of jingju melodies to be mentioned at this point is that they are based in a predominantly anhemitonic pentatonic scale, equivalent to the Western major scale omitting the 4^{th} and 7^{th} degrees, and corresponding to the pentatonic scale described in traditional Chinese music theory (Wichmann 1991: 83, Zhang$_5$ 1992: 25, “jingju” 1999: 401, Zhang$_3$ 2011: 2). Consequently, the aforementioned conjunct steps include both major seconds and minor thirds. Regarding this scale, it is described as ‘predominantly’ pentatonic because, in fact, the 4^{th} and 7^{th} degrees are actually used. During my stay in NACTA most of the musicians, actors and teachers with whom I talk referred to these two degrees as 色彩音 *secai yin*, a term also referenced by Wichmann, which she translates as “coloration tones” (1991: 83), that is, those tones that are used to confer the melody a special color. Zhang$_5$ Zhengzhi however draws on traditional Chinese music theory terminology, and refer to them as 偏音 *pianyin*, literally “leaning sounds,” as they are conceived as modifications of the neighbour scale degrees, that is, the 7^{th} degree as a half tone lowered 1^{st} degree (and therefore called 变宫 *biangong*), and the 4^{th} degree either as a half tone raised 3^{rd} degree (清角 *qingjue*) or as half tone lowered 5^{th} degree (变徵 *bianzhi*). This last case corresponds to a fa#, and indeed Zhang$_5$ argues that, even though there has been discussions about which of these two fourth degrees is the one used in jingju, both are actually present (1992: 27). Other authors, however, indicate that, compared to the equal tempered scales, the fourth degree used in jingju singing is slightly higher in pitch, and the seventh degree slightly lower (Wichmann 1991: 83, Zhang$_3$ 2011: 2). Computing pitch histograms from jingju recordings, Chen (2013) has shown evidence that this is the case.

Besides these characteristics, it can be argued that the most common element for defining *erhuang*’s and *xipi*’s melodic identity are the schemata of cadential notes (落音 *laoyin*, Table 4).[23] The most basic

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[23] Although the translation of *laoyin* as cadential notes might anticipate to the reader notions of tonal music cadences, this term seems appropriate, not only because of their function, as a tonal mark of the conclusion of a specific structural section, but even because of the shared meaning of the terms themselves. “Cadence” comes from Latin *cadentia*, which means “a falling,” and *laoyin* literally means “falling sound.” In fact, the verb *lao*, “to

		erhuang				*xipi*			
		S1	S2	S3.1	S3.2	S1	S2	S3.1	S3.2
male	opening line	2	1	3	1 (6̣)	3	2	6̣	2
male	closing line	6̣/7̣/3	7̣	6̣	2 (5̣)	3	2	2	1
female	opening line	5	1̇	6	1̇	6	6	3	6
female	closing line	6/7/3̇	7	6	5	6	6	6	5

Table 4. Preferred cadential notes in *erhuang* and *xipi*.
Based on Wichmann (1991), $Zhang_5$ (1992) and $Jiang_2$ (1995). S stands for line Section. Degrees within brackets are alternative cadential notes when a *tuoqiang* is used.

schema, and the one that every single description of these two *shengqiang* always contain, consists in the cadential notes for the opening and closing lines of the couplet, both for male and female (Table 4, notes for S3.2). The most noticeable contrast between *erhuang* and *xipi* can be observed in the cadential notes schema for male singing, which, as mentioned earlier, is considered, from a synchronic point of view, the one from which female singing is derived. In *erhuang* male singing, opening lines end on the first degree, and closing lines on the second degree (Wichmann 1991: 90, $Zhang_5$ 1992: 31, $Jiang_2$ 1995: 222, "jingju" 1999: 401, Cao 2010/1: 3, $Zhang_3$ 2011: 26), whilst in *xipi* is exactly the opposite, opening lines end on the second degree, and closing lines in the first (Wichmann 1991: 90, $Zhang_5$ 1992: 445, $Jiang_2$ 1995: 246, "jingju" 1999: 431, Cao 2010/2: 1, $Zhang_3$ 2011: 27). As for female singing, opening lines end on the higher octave first degree, and closing lines on the fifth one for *erhuang* (Wichmann 1991: 90, $Zhang_5$ 1992: 31, $Jiang_2$ 1995: 235, $Zhang_3$ 2011:26), whilst for *xipi* the cadential notes are the sixth and fifth degrees respectively for opening and closing lines (Wichmann 1991: 90, $Zhang_5$ 1992: 445, $Jiang_2$ 1995: 255, "jingju" 1999: 431, $Zhang_3$ 2011: 27). These are but only the standard cadential notes, since many other possibilities for concluding a line are considered by the authors. Of these, probably the

fall," is commonly used in jingju jargon to refer to tone with which a section concludes, by saying that it falls onto that tone.

best accounted for and agreed upon are the alternative cadential notes for male singing in *erhuang*, whose opening and closing lines might respectively end on the lower octave sixth and fifth degrees when there is a *tuoqiang* (Jiang$_2$ 1995: 224, "jingju" 1999: 401; also Cao 2010/1: 3, but without mentioning this reason; Table 4). The schemata get even more complex when the *shengqiang* is explained not in general terms but through its realisation in the *yuanban*. In these cases, cadential notes are specified for each section of the line, and even the two subsections of the third one (these are indicated in Table 4 respectively as S3.1 and S3.2). Only Wichmann offers such a schema without referring to any specific *banshi* (1991: 90). In many occasions, possible variations are also listed for any of these cadential positions. In his introduction to male *erhuang yuanban*, Shen Penfei *laoshi* pointed out that the opening line can end in any of the seven degrees of the heptatonic scale from lower octave sixth degree to the fifth degree, including the so called 'coloration tones.' He explained that choosing any of these cadential notes is not arbitrary, but followed certain rules, although for some of these rules different cadential notes are possible, and the same cadential notes are valid for different rules.[24]

From this schema, many authors conclude the modal ascription of the *shengqiang*, especially considering the cadential note of the closing line as the cadential note of the whole melodic unit. Therefore, *erhuang* is ascribed to the 商 *shang* mode (Zhang$_5$ 1992: 31, Liu$_1$ 1992: 166, Jiang$_2$ 1995: 222) and *xipi* to the *gong* mode (Zhang$_5$ 1992: 445, Liu$_1$ 1992: 320, Jiang$_2$ 1995: 246). Wichmann prefers to talk in terms of central degree, and therefore describes *erhuang* "as 2-centered, or in the key of re," and *xipi* "as 1-centered, or in the key of do" (1992: 84). From this basic common agreement some authors make more detailed remarks. Jiang$_2$ argues that melismatic extensions in male *erhuang*, resting in 5, should be considered as *zhi* mode (1995: 224) and Zhang$_5$ also considers temporal modulations (暂转调 *zan zhuandiao*) as a usual mechanism for melodic variation. Both Jiang$_2$ (1995: 246) and Liu$_1$ (1992: 319-20) argue that in male

[24] Summarizing these rules, Shen *laoshi* argues that the opening line in male *erhuang yuanban* can end in **1** when there is no melismatic extension, in **2** when the first line of the aria is sung in *daoban*, in **3** or **6̣** when there is a melismatic extension, and in **6̣**, **7̣**, **3**, **4**, **5** when the last section is compressed (紧缩 *jinsuo*).

xipi the opening line is in *shang* mode and the closing line in *gong* mode. When describing female singing, female *xipi* is considered as *zhi* mode by Zhang$_5$ (1992: 445) and Jiang$_2$ (1995: 255), whilst for female *erhuang*, the former describes it as *gong* mode transposed a fifth higher (1992: 31), and the latter maintains her ascription to *zhi* mode (1995: 235).

All the *shengqiang* characteristics described so far are, according to my experience, no commonly used by jingju performers and instrumentalists, perhaps with the exception of the schemata of cadential notes. When asked, in casual conversation, about the difference between *xipi* and *erhuang*, they[25] usually refer to two elements. The first of them is the tuning of the jinghu, a characteristic that is universally mentioned across authors. As mentioned in Section 4.1, different jinghu are used for specific *shengqiang*, and besides their acoustic characteristics, they are also tuned differently. This tuning is never explained as absolute tuning, but relative tuning, that is, what is specified is which degree of the selected scale, whose absolute pitch is decided within certain constrains according to the requirements of the singer, each of the two strings is tuned to. In *erhuang* the jinghu is tuned to **5̣** and **2**, and in *xipi* to **6̣** and **3**. In every case, even for other *shengqiang*, jinghu strings are tuned a perfect fifth apart.[26]

The second element, however, is by far the most conscious one by every jingju performer or creator, and the one that gives *shengqiang* its dramatic significance. Each *shengqiang* is described as having a set of qualities that makes it adequate for conveying a particular emotional content. Since most of these qualities and corresponding emotional content are agreed by all the scholars, it will suffice here to quote Wichmann's, who transmits her teacher Wu Junda's teachings. In Wichmann's translation, "*erhuang* is experienced as 'relatively dark, deep and profound, heavy and meticulous,'" and therefore it "is considered most expressive of grief, remembrance, and lyricism." Contrastingly, "[*x*]*ipi* is experienced as

[25] I am referring mostly to NACTA graduate or undergraduate students from the Jingju Department, either actors or actresses, or instrumentalists.

[26] I realized the secondary role of absolute tuning during my jinghu lessons. Since I did not own an instrument, I borrowed one from my teachers for playing *erhuang*, and with this same instrument I learned to play *xipi* and *erhuang* without retuning the instrument. Although every now and then we checked against the piano that the strings were tuned to C4 and G4, so that *erhuan*'s first degree was F, and *xipi*'s was E♭, we constantly checked the perfect fifth between the two strings.

'sprightly, bright and clear, energetic, forceful, and purposeful, '" so that it "is therefore considered best suited to expressing joy, delight, and vehemence" (1991: 85). As mentioned in Section 3.2, Shen Pengfei *laoshi* explained to me in his classes that when a jingju composer is confronted with new lyrics to set to music, the first step is studying their meaning (*yuyi*) and mood (*yuqi*), and according to that select the *shengqiang* that better fits the lyrics' emotional content, and, since *shenqiang* is an inner structure, also a corresponding *banshi*.

4.5. *Banshi*

Banshi is the element of jingju musical system that is the closest to the melodic surface. An enlightening approach to its understanding can be the analysis of its literal meaning. The original meaning of *ban* refers to the already mentioned wooden clappers. As previously explained, the function of this instrument is to signal the strong beats of the metrical units, and therefore, *ban* acquires in this context the meaning of meter itself. 式 *Shi* literally means 'type, style,' and extensively 'pattern' and 'form.' Consequently, *banshi* can be understood as the way the *ban* clappers play, and more specifically, the metrical pattern this playing signals.

If most Chinese scholars describe the characteristics of each *banshi* without needing to provide a definition of this concept, Zhang$_3$ Yunqing attempts to explain what a *banshi* is. According to this author, "*banshi* is the collective name given to different types of accented and unaccented beats [*ban*, *yan*] with a fixed metre [节拍 *jiepai*], or pitch and rhythmic freedom without a fixed metre" (2011: 65). From this definition it is ostensible that the most significant aspect in the definition of *banshi* is meter. The accented and unaccented beats mentioned by Zhang$_3$ correspond to the categories of beats usually considered in traditional terminology. The accented beats are called the same as the instrument that marks them, *ban*, while the unaccented beats are called *yan*, literally 'eye.' In this way, a metre is defined by the number of *ban* and eyes that form it. In jingju, theoreticians speak of mainly four metres: 一板一眼 *yi ban yi yan*, 'one *ban* and one eye,' 一板三眼 *yi ban san yan*, 'one *ban* and three eyes,' 有板无眼, '*ban* but no eye,' and 无板无眼, 'no *ban* and no eye.' The *banshi* that use the first three metres are collectively known as belonging to the 上板类 *shangban lei*, literally the ‘on *ban* type,’ which can be understood as metred types. These three metres are usually notated in *jianpu* scores correspondingly with the time signatures 2/4, 4/4 and 1/4. As for those that use the fourth metre, they are assigned to the 散板类 *sanban lei*, literally ‘scattered *ban* type,’ understood as unmetred types. In *jianpu* notation, passages in these metres are written down without time signature or with the symbol サ, reduction of 散 *san*, ‘scattered.’ In order to ease readability, I will refer to the first three metres by their associated key signature, and the fourth as free metre.

In Western scholarship, some authors stress this metrical aspect of *banshi*, as can be observed from the different translations they offer, such as “metrical structures” (Stock 1993: 233), “metrical form” (Stock 1999: 193), or “metrical types” (Wichmann 1991: 53). However, for those authors who consider *shengqiang* as tune families, *banshi* are the tunes that form these families. Both Rulan Chao Pian (1972) and Bell Yung (1989) interestingly define *banshi* (or in the case of the latter the equivalent element in Cantones yueju, namely *bongwong*) as ‘aria types.’ According to the conception of *shengqiang*, these aria types should be understood mainly as tunes, and therefore these authors confer melodic features to each *banshi*. The use of the term aria, generally used to define a form, testify that these authors analyse *banshi* in its superficial melodic realisation, hence combining the melodic framework provided by the *shengqiang* in its final concretization through a specific *banshi*. Only Schönfelder decides not to translate, at least fully, the term, and refers to it as “ban-Form,” an approach closer to the one taken in this thesis.

The understanding of *banshi* as tunes might be motivated by the fact that the metrical changes that each *banshi* brings to the *shengqiang* melodic framework also produces other transformations with melodic implications. Wichmann, defining the features of *banshi*, explains that each of them “has a characteristic tempo, is associated with certain characteristic melodic tendencies, and is perceived as appropriate for certain dramatic situations” (1991: 59). These three aspects are commonly agreed among scholars, so I will look at them individually.

Together with metre, the second most significant characteristic of a specific *banshi* is a certain tempo range. In fact, judging from the very names that *banshi* receive, tempo might be the most prominent element for jingju performers and musicians. As already mentioned, it is a general agreement to assign the melodic material of a *shengqiang*, when presented in the form that is conceived as the closest to the original one, to a specific *banshi*, which is consequently called *yuanban*. Most of *banshi* names are composed by two elements, of which the second one is generally *ban*, which can be understood as an abbreviation of *banshi*. The first component points to the main characteristic of that *banshi*. In the case of *yuanban*, *yuan* literally means 'primary, original,' and therefore all *banshi* are understood as transformations of the melody assigned to this *banshi*. Conventionally, this *banshi* is associated to a 2/4 metre and to a moderate tempo range. If in all cases *banshi* in female singing are performed in a slower tempo when compared to their male singing counterparts, in the case of female *xipi*, *yuanban* is conventionally performed as 4/4. When *yuanban* is transformed into a 4/4 metre, the tempo range is also shifted to slower values. In fact, the resulting *banshi* is called *manban*, in which *man* literally means 'slow.' On the other hand, when it is transformed into a 1/4 metre, the tempo is also raised, and the resulting *banshi* is consequently called 快板 *kuaiban*, where *kuai* means 'fast'. Therefore, as can be observed from their very names, tempo is a key element in the conception of *banshi*. The importance of tempo for *banshi* definition is specially ostensible in metred *banshi*. When *yuanban* is transformed into a free metre form, a resulting *banshi* can be called 散板 *sanban*, where *san* literally means 'scattered.' The basic logic that informs the *banshi* system, and in general the whole metric changes system, to which other xiqu genres of the *pihuang* and *bangzi* systems belong, is that an original melody can be metrically stretched and slowed down, compressed and accelerated, or even 'scattered' into an unmetred form.

As a result of the previous logic, in each transformation melodic and rhythmic changes are also produced, and these elements become defining traits of each *banshi*. The transformation process from *yuanban* to *manban*, even though it maintains the lyrics' rhythmic structure, does not merely consists in multiplying the duration value of each note and slowing down the tempo, but the longer temporal span between sung syllables is filled with a richer ornamentation of each sung syllable. More noticeable changes occur in the transformation process from *yuanban* to *kuaiban*, since the metrical reduction provokes a necessary alteration of the lyrics' rhythmic structure, and the singing style becomes almost syllabic. When the transformation process goes towards unmetred *banshi*, the performer or arranger of the melody has even more freedom to alter the 'original melody.' In this thesis, I will refer to this ratio of pitch changes per syllable as melodic density. The different melodic densities of each *banshi* confer them a specific melodic identity that might be at the basis of their consideration by authors such as Yung or Pian as 'tunes' or 'aria types.' It has to be taken into account however, that the characteristics of the *banshi* do not represent the melodic surface of an actual aria, but other factors, such as role type, linguistic tones, and the creative personality of the performer or arranger, contribute to the final contour of the melody.

The specific number of *banshi* varies across authors, as well as their classification method. Previously I mentioned two commonly agreed categories, such us metred and unmetred *banshi*, and four specific *banshi*, the 'original' *yuanban*, its slowed transformation, *manban*, its accelerated transformation, *kuaiban*, and its unmetred transformation, *sanban*. Regarding the first three metred *banshi*, they can be understood as located in a continuous tempo range, in which *yuanban* occupies the centre with a moderate tempo, *manban* lies at the slowest extreme, and *kuaiban* lies at the fastest one. However, between the centre and each extreme there are different *banshi* associated to increasingly slower or faster tempo ranges. An alternative name for 三眼 *manban* is *sanyan*, 'three eyes,' clearly referring to the three unaccented beats of the 4/4 metre. Three different *banshi* are derived from this name, namely 慢三眼 *mansanyan*, 中三眼 *zhongsanyan*, and 快三眼 *kuaisanyan*, respectively slow, medium and fast *sanyan*. When the term *manban*, or just *sanyan*, is used, it is the equivalent to *mansanyan*, the slowest of these three stages ($Zhang_5$ 1992: 100). The only other *banshi* in 2/4 is known as 二六 *erliu*, literally 'two six.'[27] Moving towards the *kuaiban* extreme, there is a common intermediate step known as *liushui*, literally 'running water,' which is also performed in 1/4 metre, but slower than *kuaiban*. Regarding the unmetred *banshi*, besides the already mentioned *sanban*, there is another unmetred one called

[27] The meaning of this *banshi*'s name is disputed, and it is attributed to the total length in measures of the original common instrumental prelude, or as a homonymic use instead of 二流 *erliu*, literally 'second range,' referring to its tempo (Liu_1 1992: 365).

摇板 *yaoban*, in which *yao* means ‘shaking, rocking.’ According to the literature, the difference between these two *banshi* is located in the accompaniment. Whilst in *sanban* the instrumental ensemble follows the same melody as the vocal melody, in *yaoban* the vocal melody maintains a free character similar to *sanban*, but over an energetic accompaniment in 1/4 meter (Liu$_1$ 1992: 254, Zhang$_5$ 1992: 215, “jingju” 1999: 416, Cao 2010/1: 125). Because of this characteristic, it is commonly described as 紧打慢唱 *jin da man chang*, ‘tight beating, and slow singing.’

All the *banshi* described so far can be used for arranging a whole aria or a whole section of an aria, for as many couplets as needed. However, there are other *banshi* whose use is restricted to a limited number of lines. Among these, the most frequent one is 导板 *daoban*, where *dao* means ‘leading.’ Indeed, this *banshi* is restricted to the first opening line of an aria, when is needed to be sang in specially intense and lengthy unmetred form. The aria continues henceforth with a metred *banshi*. 回龙 *huilong* is another of these *banshi*, that is only used after a *daoban*, and before entering in the main *banshi* of the aria. It is sung in a contrasting fast, 1/4 meter, and it is generally used when the closing line following the preceding *daoban* contains piled characters. Occasionally, *huilong* can be prolonged beyond the first closing line to the next couplet. In any case, after it the aria enters in its main *banshi*. When these piled characters appear in a central line of an aria, they are also sung in a fast, 1/4 metre, a convention that is identified with another *banshi* called *duoban*. The fourth of these common special *banshi* is the so called 哭头 *kutou*, literally ‘crying head.’ It is used for a grievous outburst, in which the singing emulates a weeping lament, that can occur after any section of the couplet, over some filling characters in form of interjection, that are sung in an unmetred, sorrowful way, which breaks the regular rhythmic structure of both music and lyrics.

The *banshi* mentioned so far are just but some of the most frequent ones. However, there is no closed list of *banshi*, and different authors might consider more than these. Some of the authors attempt a classification of the *banshi* beyond the categories of metred and unmetred. Those special *banshi* with restricted use are commonly considered as auxiliary (附属 *fushu* in Zhang$_5$ 1992: 2-3, and Jiang$_2$ 1995: 243; 辅助 *fuzhu* in “jingju” 1999: 401, 431). Those that can be freely used to arrange a whole aria are classified as main (主要 *zhuyao* in Zhang$_5$ 1992: 2, 主体 *zhuti* in Jiang$_2$ 1995: 242) or basic (基本 *jiben*, in “jingju” 1999: 401, 431) *banshi*. Zhang$_5$ Zhengzhi goes even further and consider basic *banshi* only the four ones that where firstly mentioned here, namely *yuanban*, *manban*, *kuaiban*, and *sanban*, while the rest of not auxiliary *banshi* are considered as derived (派生 *paisheng*) *banshi*, since the author understands that they evolved from the main ones.

These variety of *banshi* is required in order to convey the emotional content of the lyrics, since each of them is associated to a specific expressive content, as it is mentioned in the quote by Wichmann cited previously. If *banshi* can be conceived as aligned onto a continuum of tempo and metre, their expressive content can be also understood as such a continuun. In general terms, *yuanban*, in the centre of this continuum, is associated with a rather neutral, narrative content, in which some information is provided without a clear emotional charge. As the *banshi* get closer to

		tempo	metre	function
main *banshi*	*manban* (*sanyan*, *mansanyan*)	slow	4/4	introspection, reflection
	zhongsanyan		4/4	
	kuaisanyan		4/4	
	yuanban	**moderate**	**2/4**	**neutral, narrative**
	erliu		2/4	
	liushui		1/4	
	kuaiban	fast	1/4	agitation, nervousness
	sanban	N/A	free	lyricism, emotion
	yaoban	(fast acc.)	free	
auxiliary *ban.*	*daoban*	N/A	free	aria’s first line
	huilong	fast	1/4 (2/4)	line(s) after *daoban*
	duoban	fast	1/4 (2/4)	in-line (piled characters)
	kutou	N/A	free	grief (extra characters)

Table 5. Most commonly used *banshi*.

the *manban* extreme, they acquire an introspective, reflective, deep mood, whilst towards the *kuaiban* extreme they express agitation and nervousness, from emotions such as anger, fear, stress, etc. Unmetred *banshi* have a wider application expressive range, but generally confer a lyrical, intense character to the emotion expressed. With the expressive content of the *banshi*, the emotional atmosphere conveyed by the *shengqiang* becomes more concrete and specific. Therefore, the emotional and expressive content of both *shengqiang* and *banshi* has to be aligned with each other. In the case of *erhuang*, the expressive function of those metred *banshi* faster than *yuanban* escape from the emotional framework of the *shengqiang*, and consequently, traditional plays do not use those *banshi* in *erhuang*. Table 5 gives a summary of the *banshi* presented in the previous paragraphs. For an example of how different *banshi* are used in one *changduan*, see Figure 1.

4.6. Conclusions

In this chapter I have presented the common understanding of the jingju musical system according to the traditional approach established by the Chinese scholarship, with special focus on the concept of *shengqiang*. This description defines the theoretical framework that will guide the implementation of the methodology proposed in Chapter 3, including the creation of the research corpus Chapter 5 and the comparative analysis Chapter 7. I will summarize here the main outcomes learnt from this revision.

The melody of a jingju aria is defined by a series of contingent and systemic factors. The first ones are dependent on the specifics of a particular performance, and related to prosodic elements of the lyrics, their content, the personality of the character, the dramatic context, and the singing style of the performer, determined either by his or her performing school or his or her own creativity. These factors are related to the details of a specific case, and can not be abstracted into general characteristics that identify jingju as a whole. Consequently, these factors have not been analysed in this chapter. The second ones can be understood as the conventions that the jingju tradition have developed for the arrangement to music of new lyrics. These set of conventions defines the jingju musical system

—although in this case just focused on singing. This system is formed by four main elements, namely role type, *shengqiang*, *banshi* and lyrics structure.

A second important outcome is that *shengqiang*, as the result of the previous description, is an underlying melody, which is not explicitly present in the melodic surface of performed arias, but should be inferred from them—and this the aim of the proposed methodology (Chapter ???). However, since at the level of musical system, there are other three main elements influencing the final melody, each of them should be also taken into account in order to discriminate which traits of the sung melody belong to each of these elements, and from that determine those which characterise *shengqiang*. Consequently, these four elements of the jingju musical system will frame the corpus creation, the comparative analyses, and the development of computational tools undertaken in this thesis.

Regarding the role types, the aspect that is relevant for my research is the singing skill. In this regard, the most important factor is their division into male and female singing. The main characteristic of this division is the difference in terms of pitch range. Since the main representative role types for each singing are, respectively, *laosheng* and *dan*, the creation of the corpus and the performed analysis will focus on these role types, and will secondarily also consider other role types whose main skill is singing, such as *jing* and *laodan* for male singing, and *xiaosheng* for female singing. On the other hand, computational tools can support the analysis of the influence of role type by extracting information about pitch space.

Regarding *shengqiang*, two main approaches are observed in the reviewed literature. According to the first one, it is described as a tune, with a melodic contour of its own. However, either an example of an actual aria (generally in *yuanban*) is given, from which the inference of the underlying elements related to *shengqiang* is left to the reader, or a basic melodic contour is provided, although no explanation about its origin—the result of an analysis, a common assumption within jingju circles, or just a conclusion of the author's personal experience—is provided. The goal of this thesis is to tackle precisely this shortcoming, and to provide a melodic description of *shengqiang* that is empirically inferred from data. According to the second approach, a series of general characteristics are offered about each *shengqiang*, among which the most relevant ones are the cadential notes, the use of intervals, the pitch material—the predominantly pentatonic scale and the two coloration tones—, and the melodic density. Computational tools can help study these features from quantitative data. Finally, this thesis is concerned with the two main *shengqiang* in jingju, *xipi* and *erhuang*, and for the creation of the corpus this will be the guiding principle.

Jingju music is explained in this tradition through *banshi*. This element affects mostly the temporal factors, such as tempo and metre. Since each *banshi* is understood as a specific realization of the underlying *shengqiang* common to all of them, the characteristics related to *banshi* are the ones to be removed in order to reach the *shengqiang*. Consequently, the *banshi* will guide the grouping of data for coherent comparison, but the goal of the analysis is to find the commonalities below them. Therefore, temporal aspects will be not considered during the performed analyses.

Finally, since the couplet is understood as the basic melodic unit, it will be also the basic analytical unit. More specifically, since it shows structural differences between their opening and closing lines, it will be the melodic line, together with the three previous elements, namely role type, *shengqiang* and *banshi*, the four systemic elements that define the analytical categories. In this sense, the analysis will be performed separately for opening and closing lines. In the case of *erhuang*, two options are available as opening line for a given couplet, and therefore they will be considered also separately. Consequently, in *erhuang* three line types are defined, namely opening line 1, which refers to its longer version, opening line 2, when it takes the same structure as the closing line, and the closing line itself. In the case of *xipi*, two line types are considered, opening line and closing line. For the analysis of each melodic line, its own inner structure of three sections will be considered. For this analysis, statistical information about the pitch space in each of these sections will provide useful insights, and therefore computational tools for extracting such information will be developed.

Chapter 5 Jingju Music Corpus

According with the methodology described in Chapter 3, the analysis of jingju music carried out in this thesis follows a data driven approach. This approach implies the creation of a corpus that is suitable for the proposed research goals and corresponding methodology. As concluded in Chapter 2, the existing databases at the beginning of this research which are accessible do not present enough data and related information to satisfy the purpose of this thesis. On the other hand, in the framework of the CompMusic project, within which this research has been carried out, an important effort was put in the creation of research corpora for each of the studied music tradition, an effort to which I contributed and from which I benefited for my own research goals. As a result of it, the Jingju Music Corpus (JMC) was created, formed by four different collections of data, namely audio recordings from commercial releases, machine readable music scores, newly produced *a cappella* recordings and machine readable lyrics. Of these four collections, this thesis takes the music scores as research object. The JMC was created for broader goals than they research task addressed in this thesis, and is the result of a collaborative work of different CompMusic members. However, since during the first stages of my research an important workload was dedicated to the creation of this corpus in the pursue for the most adequate data, the JMC will be presented here in its entirety, specifying in every moment which are my personal contributions, and focusing on the data used in this thesis.

Considering the corpus driven approach assumed in the CompMusic project, the quality of the undertaken research directly depends on the quality of the corpora. However, at the beginning of the project no standard framework was established in the MIR community for such a task, and therefore the building of a scientifically efficient corpus for data-driven research became a research task in itself, as discussed by Serra (2014). Two important outcomes resulted from this research, that have guided the data gathering and management in the project. Firstly, two different types of data collections are considered, namely research corpus and test corpus. According to his definition,

> [r]esearch corpora are collections of authentic data used to perform experiments to advance knowledge. The test corpora are the ground truths, collections of authentic or invented data used for testing, evaluating performance, and calibrating the tools used in experimentation. (Serra 2014: 27)

During the development of the project, the definition of these two concepts have been acquiring more precision. Research corpora, or simply corpora, since they are aimed at advancing knowledge, can be in a continuous process of growth, as long as new authentic data that satisfy the criteria for which a corpus is created are collected. Test corpora, which nowadays are more commonly referred to as datasets in the CompMusic project, are put together for a specific research task.

Differently from corpora, which are formed by 'authentic data,' datasets might be formed by a subset of a related corpus, that is, by authentic data, plus data from outside the corpus, either authentic or artificially generated, which complete the requirements of the corresponding research task. Data in these datasets are usually accompanied by annotations or extracted features, aimed at solving the purpose for which they were created. Since datasets are gathered for a specific purpose, and considering the aim for reproducibility to which the CompMusic project is committed, datasets are considered as fixed and unalterable in the future, always related to a specific undertaken research task—and to its corresponding publication. In the framework of the CompMusic project, a research corpus is built for each of the five studied music traditions, as well as several datasets for each of them addressing specific research tasks.[1]

[1] An overall presentation of the CompMusic research corpora and datasets can be found in http://compmusic.upf.edu/corpora. For more detailed descriptions, please refer to Srinivasamurthy et al. (2014b) for the Hindustani and Carnatic music corpora, Uyar et al. (2014) and Şentürk (2016) for the Ottoman-Turkish makam music corpus, and Sordo et al. (2014) and Caro et al. (2018) for the Arab-Andalusian music corpus. An initial presentation of the jingju music corpus was made by Caro and Serra (2014, 2017a).

Secondly, in other to evaluate the quality of each corpus and therefore understand the shortcomings that needed to be addressed, Serra proposed five criteria, namely *purpose*, that is, “the research problem that wants to be addressed and the research approach that will be used,” *coverage*, understood as the inclusion in the corpus of “enough samples of each instance for the data to be statistically significant,” *completeness*, meaning the “percentage of [data] fields filled,” which in this project’s case is directly related to editorial metadata and related descriptive information, *quality*, not only of the data, but of the related metadata and information, and *reusability*, considering the goal that “[t]he research results have to be reproducible and that means that the corpus has to be available for the research community to use.” (2014: 2–3). In the following sections of this chapter, I will describe each of the collections of the research corpus created for the research of jingju music using these five criteria.

However, before delving into each particular collection, it should be pointed out that the main general purpose for the creation of the JMC is the research of traditional jingju singing. In the definition of this research object, traditional and singing are key concepts. The focus on singing has two main motivations. Firstly, we argue that, according to the jingju musical system described in Chapter 4, singing is the core of the musical dimension of jingju. With the exception of instrumental tunes (see Section 4.1) and some percussion patterns, used for specific scenic settings and accompanying other performance skills such as physical acting and especially acrobatics, all musical elements in jingju are put at the service of singing. As a consequence, the aria is considered as the basic unit for the creation of each of the different collections of the corpus. This implies that each collection is formed by arias, and broader sections like scenes or plays have not been considered for building the corpus. The second motivation is related to the research framework in which this work has been carried out. For each of the music traditions researched in the CompMusic project, the vocal repertoire has been the main focus. The motivation behind this decision was to maintain a unifying principle across the project’s five corpora, so that technologies for specific tasks might be shared across corpora, even though specific adjustments were needed according to each music culture, and also with the aim of proposing cross-cultural studies, crossing data from different music traditions.

The focus on traditional repertoire is motivated by the aim of understanding the jingju musical system before the incorporation of academic composition techniques that were introduced in the second quarter of the 20th century. The composer of jingju music, if always rooted in the jingju musical system, without which the genre would loose its identity, adds to this system a new level of complexity which is the conscious seek for originality. Since it crystallized at the end of the 19th century, jingju music has been continuously evolving, and gaining refinement and complexity. No doubt, the great jingju stars at the beginning of the 20th century, competing in the context of a jingju market, strove for the development of original, individual performing styles that allowed them to stand out from their competitors. The innovations introduced by these performers, in general terms, were the result of expanding the elements of the musical system accumulated by previous generations by means of the performative knowledge gained through direct experience (Li_2 2010: 54). And since the individuality and personality of different styles is always acknowledged for these performers, this process is still understood within jingju circles as arrangement. As learnt from the literature review (Section 2.1) and confirmed during my fieldwork in NACTA (Section 3.2), the jingju music composer, in his or her seek for innovation, positions him- or herself in a different conceptual framework, which is the intellectual work guided by his or her theoretical knowledge. From this standpoint, the composer consciously aims at creating new elements, at challenging the boundaries of the musical system and experimenting with conceptual, rather than performative, components. For this process, the composer brings in a series of techniques learnt from European academic composition that become a new aesthetic principle for the newly composed plays. The development of this compositional trend did not mean the substitution of the previous ways for jingju music creation, which continued evolving. This trend aims at maintaining the aesthetic principles of the newly created plays within the scope of the repertoire that existed before the arrival of compositional techniques, although it also incorporates some of them, more related to practicalities—of which composition through notation might be the most relevant one (Guy 2005: 132)—, than to music creation principles, such us phrasing, pitch range, metre, harmonization and instrumentation, which were indeed also used.

These approaches go beyond music creation and affect the conception of the work as a whole, concerning aspects such us the main theme, the plot, the lyrics, acting, costumes and make-up, and scenography. As a result, nowadays there are three broad categories of plays considered within jingju circles. All the plays that were performed before the new techniques were brought in are known collectively as 传统戏 *chuantong xi*, traditional plays. Those plays in which the transformation of jingju is sought as an aesthetic goal, which address themes and plots that were not usually addressed, and exploit European academic techniques are known as *xiandai xi*, modern plays, among which the most representative ones are the revolutionary plays.[2] Finally, those newly composed plays that aim at remain within the creative ways of the traditional plays are known as *xin bian lishi ju*, newly arranged historical plays.

The research carried out in the CompMusic project aims at pushing forward the state of the art in MIR by addressing the specificities of music traditions that were not commonly researched within this field. We argue that in the case of jingju music, this specificities are more ostensible in traditional plays, since they lack the complexities added by the compositional techniques of the other two categories of jingju plays. As a consequence, the JMC is formed by arias of traditional plays, although in some cases, especially for those role types that found a great development within newly arranged historical plays, those arias that now form the standard repertoire for these role types have also been included.

The JMC is the result of a collective effort by different members of the CompMusic team. In the following sections I will focus on the work in which I have been directly involved, and will just briefly present other parts of the JMC, whose details have been published elsewhere, in order to provide here a general description of the corpus as a whole.[3] Finally, all

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[2] For a historical account of the development of modern plays, see Mackerras (1988b). For their impact in actors and actresses careers and skills, see Li$_2$ (2010). For the musical novelties of these plays through the detailed analysis of one them, see Mittler (2003).

[3] For the description of the corpus I draw on the terminology use in MusicBrainz (https://musicbrainz.org), the open music encyclopedia for music metadata. Specifically, I use the following terms: release, for the specific issue of a publication, such a CD, recording, for each of the individual ordered tracks contained in a release, artist, for any performer recorded, both individual or collective, such as accompanying ensembles, and work, for the original piece or any of its parts of which a recording registers a specific performance by a specific individual or group of artists. Please refer to MusicBrainz documentation for more

the information about the access to each of the collections here, can be found in the thesis' companion web page.[4]

5.1. Jingju Audio Recordings Collection (JARC)

The collections of audio recordings are the most important component of each of the corpora built in the CompMusic project, and the first one that were collected. This was also the case for the JMC, whose first collection to be built was the Jingju Audio Recordings Collection (JARC).[5] It is formed by 91 commercial CD releases, published during the last four decades, which cover 1244 recordings and more than 119 hours of audio[6] as total numbers in Table 6 show. Hereunder I will describe the collection

detailed information (https://musicbrainz.org/doc/MusicBrainz_Documentation).

[4] http://compmusic.upf.edu/caro2018thesis

[5] The JMC was first presented in the 15th International Society for Music Information Retrieval Conference in 2014 (Caro 2014), and in that initial stage it consisted mostly in the JARC. I present here updated numbers and a more detailed description.

[6] The CDs were acquired through three purchases. The first one was done before I joined the project. Chen Kainan, a master student working in CompMusic, bought the collection 《京剧之星》 *Jingju zhi xing*, *Stars of jingju*, plus other few releases at the end of 2012 (personal communication). The second was made during my first research stay in NACTA in 2014. The 北京京昆李元书店 *Beijing jing kun Liyuan shudian*, Beijing jingju and kunju store *The pear garden* (http://www.shu8.com/) bookshop in NACTA is specialized in xiqu related materials, including books, printed scores and audio and video recordings. I explained our criteria to the shopkeeper and asked for all the existing CDs that met such criteria. Finally, during a series of visits to Chinese universities and research centers in 2015, I found CDs not included in our collection in the store of the Mei Lanfang grand theatre.

During an informal conversation after one those meetings, 江松松 Jiang Songsong *laoshi*, a sound engineer working in NACTA, who also had worked for some recordings labels were several jingju performers recorded compilations of arias as the ones included in the JARC, shared with us interesting observations about the function of CD releases within jingju circles. He claimed that, as a theatrical art form, most aficionados enjoy jingju in live performance, and it is mostly amateur singers those who would listen to recordings in order to learn from acknowledged performers. Indeed, many of the releases in the JARC contain few tracks, or even a whole extra CD, for just the instrumental accompaniment, so that the amateur performer can sing along. For these cases, amateurs would prefer the old masters, from whom there are existing recordings, over young performers. Therefore, these young performers would rely more on their live performances than on recorded releases for building their careers, and only when they have established a reputation, they would record a compilation of arias as an outcome of a long professional career. As a consequence, both artists and labels find few incentives to engage in the recording of jingju arias. Furthermore, those releases are usually published in one single edition, and are rarely reissued.

role type	artists	recordings	time
laosheng	24	415	38h 18’ 11”
xiaosheng	9	67	6h 13’ 34”
wusheng	3	5	18’ 3”
dan	29	483	49h 20’ 38”
laodan	11	171	17h 16’ 11”
jing	7	91	7h 37’ 33”
chou	2	8	19’ 48”
wuchou	1	4	11’ 40”
Total	86	1244	119h 35’ 38”

Table 6. Content of the JARC in terms of role types.

according to the previously mentioned five criteria proposed by Serra (2014).

- ***Purpose***: Being the initial collection that formed the JMC, its purpose aligns completely with the general purpose for the JMC, that is, the research of traditional jingju singing. According to the implications described previously regarding the focus on jingju singing and traditional repertoire, the standard unit for building the JARC has been the aria from traditional plays. Consequently, for building this collection we gathered albums that contain one aria per track, and discarded recordings of full scenes or plays, in order to save the vast amount of work required for manually splitting those tracks into aria files. The market also offers a great number of DVD and VCD releases, which in their vast majority consist in full performances. Therefore, we did not considered video releases for the JARC, and limited our collection to CDs.
- ***Coverage***: Most of the CDs that meet the aforementioned criteria consist in compilations of arias sung by a single performer. Consequently, the main criterion for selecting a release to be included in the JARC is the role type in which the featured performer is specialized. According to the collection’s purpose, we have fo-

cused on those role types for which the singing skill holds a preeminent position, namely *laosheng*, *jing* and *laodan* for male singing, and *dan* and *xiaosheng* for female singing. Secondly, we have discarded those releases containing modern plays, since our purpose is to research traditional jingju singing. However, some collective releases include other role types such as 武生 *wusheng* and *chou*, and in some individual releases, the performer might include one or few arias from modern plays. These recordings are also part of the JARC. Since it is the performer, and therefore the role type, the central element of the releases, they could not be chosen in terms of the *shengqiang* or *banshi* they cover. Consequently, we argue that the statistics about *shengqiang* and *banshi* obtained from this collection reflects the preferences in terms of these two elements in the standard repertoire of the main singing role types.

	eh.	*xipi*	others
manban (*sanyan*, *mansanyan*)	180	112	74
zhongsanyan	9	1	2
kuaisanyan	42	10	2
yuanban	232	192	75
erliu	9	145	18
liushui		179	3
kuaiban	4	120	6
sanban	138	149	50
yaoban	28	133	13
daoban	114	188	18
huilong	83	11	17
duoban	25	12	6
kutou	2	8	3
others	32	1	96

Table 7. Content of the JARC in terms of *shengqiang* and *banshi*. Number of recordings containing the given combinations of *shengqiang* (columns) and *banshi* (lines). *eh*. stands for *erhuang*

With this information, the coverage of the JARC in terms of its purpose, can be assessed. As described in Chapter 4 jingju singing can be characterised by the three main elements of the jingju musical system, namely role type, *shengqiang* and *banshi*. Regarding the first, all the five main role types for which singing is an important skill are included and well represented in the JARC, with a clear predominance of *laosheng* and *dan*, which respectively are the representative roles for male and female singing. Table 6 gives more detailed information. As for *shengqiang*, *xipi* and *erhuang*, account for almost 85% of the whole collection, while the rest of *shengqiang* are clearly underrepresented. This clearly shows how *erhuang* and *xipi* are the two most representative jingju *shengqiang*. Since no *shengqiang* can be sung without a *banshi*, Table 7 shows that all the main ones, as described in Section 4.5, are well represented. Consequently, I argue that the JARC has a good coverage of the elements that form the research object for which the collection was created.

Finally, even though the works covered in the JARC are not a relevant factor for our analysis, since as a prerequisite we already restricted the collection to the traditional repertoire and the object of our analysis is the musical system shared by these works, it is interesting to observe that the collection covers 660 arias from 270 plays. These numbers should be taken with caution because of the difficulties for aria, or even play, segmentation discussed in Section 4.1. To this characteristic, it has to be added the fact that many plays have different names. In those cases where I have observed this circumstance, I have unified the name of the work recorded, as explained below. The work to which each recording is related has an important role in the JMC, since it is the main element through which the different collections are interrelated.

- ***Completeness***: All the editorial metadata from the releases were manually uploaded to MusicBrainz (MB).[7] This repository of music metadata assigns a unique identifier to each of the entities that form a release, such as the release itself, the recording, the artists and the works. It is this MB identifier (MBID) the token by which each recording in the JARC is identified and retrieved. Besides, MB also allows the establishment of labeled relationships between these entities, which we use for structuring and organ-

[7] The metadata for the JARC are stored in a MB collection named Dunya Beijing Opera (https://musicbrainz.org/collection/40d0978b-0796-4734-9fd4-2b3ebe0f664c).

ising the collection. Metadata are stored and uploaded to MB in its original Chinese. The title of releases, recordings and works, as well as the name of each artist were also introduced in pinyin in order to ease searching by users who do not read Chinese.[8] In the case of MB, a pseudo-release is created for each release, with its title and the title of each recording in pinyin. For the name of artists and works, their pinyin was included as aliases. In cases where the same work receives different names in different releases, I take the one used in the *Dictionary of jingju* (Wu_1 2007) as the main one, and added the related names as aliases. Information about role type has been included as a tag related to each artist, and information about *shengqiang* and *banshi* has been included as single tags for each recording, one for each combination of these two elements contained in the recording. *Shengqiang* and *banshi* have not been directly related to works because in some occasions different recordings of the same work present discrepancies about this information. Covers and related art work, including booklets, for each release are made also available in MB. Besides these data, the editorial metadata of the recordings also include the recording label, catalog number, the release date, the recording date, and the barcode of the release. However, the release date, and especially the recording date, is missing in an important number of releases.

- ***Quality***: The JARC contains recordings of enough quality for being used in computational research. There exist many recordings in the market from old masters in live performance, available in remastered editions, which still present too much noise and too poor recording quality to be useful for the methods implemented in the CompMusic project. After a preliminary test with some of these recordings, we decided that they should be discarded from our collection. Consequently, the JARC is limited to recent releases recorded in studio with a sound quality that meets the standards required for computational research. Although, as mentioned previously, many of these releases lack the recording year,

[8] For the revision of the pinyin and their uploading to MB I was helped by Chen Kainan and Yang Yile, master students members of the CompMusic project.

by the age of the recorded artists it can be inferred that these releases have been issued within the past four decades. All recordings were ripped in a lossless compressed format with a sampling rate of 44.1 kHz.

The editorial metadata have been obtained from the covers and booklets included in the releases. Although in some cases discrepancies are found in terms of *banshi*, and only very rarely in terms of *shengqiang*, we kept the original information so that it can be a research object in itself. The only discrepancies that were unified are those about work names, as explained previously.

- ***Reusability***: Since the recordings comprised in the JARC are commercial recordings, their reusability is limited to research purposes according to the applying legislation. The editorial metadata are freely available. The thesis' companion web page gives the details for accessing the contents.

When I first joined the CompMusic project, I expected audio recordings to be the main source for my research. I hoped that possibilities that computational tools offer for working directly with the audio signal will allow to overcome the limitations inherent to other more indirect representations of the music, mostly music notation, and therefore benefit from the subtleties recorded in these audio signals. Since the research object is jingju singing, the preliminary required step for any related analysis consists in the extraction of the sung melodic line. However, this turned out to be a specially challenging task for the case of jingju music recordings.

In preliminary experiments, two major problems arose that complicated the extraction of the sung melodic line. Firstly, the pitch track extracted using state of the art algorithms are not satisfactory enough. The algorithm that was commonly used in the team for the task of predominant melody extraction was the one developed by Salamon and Gómez (2012), which is the state of the art algorithm for predominant melody extraction from polyphonic sources. According to the authors, it was tested in 2010 and 2011 editions of the Music Information Retrieval Evaluation eXchange (MIREX), using four music collections that contain audio recording clips of genres such as pop, jazz, opera, rock, R&B, classical piano, north Indian classical vocal music, and "Karaoke recordings of Chinese songs" (Salamon 2012: 1766). In the development process of this algorithm hence music traditions like jingju were not considered, and therefore it does not address the specific characteristics of the jingju musical system. Consequently, the results produced by this algorithm are not optimal for jingju. In his master thesis, Chen observed that the most common error produced by Salamon and Gómez's algorithm when implemented in jingju music recordings is the octave error, which in a preliminary evaluation through listening by Chen, stands between 1% to 10% of the recording, but reaching 60% in one particular case (2013: 22).

In a preliminary study carried out by myself in collaboration with other CompMusic researchers (Caro et al. 2015), with the goal of testing the potential of state of the art tools, I created and analysed a test dataset of eight selected recordings from the JARC. After extracting the predominant melody using Salamon and Gómez's method, I had to manually correct an average of 7.16% of the results (Caro et al. 2015: 509) using the Sonic Visualiser software (Cannam et al. 2010). Sankalp Gulati, a researcher from the CompMusic project with whom I collaborated in initial studies of jingju music recordings from the JARC, analysed the behavior of this algorithm when applied to jingju music and observed some factors that can explain the lack of satisfactory results.[9] Gulati points out four characteristics of jingju music that hinders the performance of state of the art algorithms, namely the high pitch content, which reduces the number of harmonics available in the spectral domain to detect the fundamental frequency, rapid pitch movements, which contravene streaming cues that constraint the pitch movement variability allowed for considering a continuous melodic line, frequent variations in loudness and timbre, which can go beyond the stability thresholds contained in this algorithm, and finally the close resemblance of the accompaniment, especially the jinghu line, with the voice, both in terms of timbre and melody, which, together with the loudness and timbre variations just mentioned, results in that the

[9] This collaboration took place in the context of the preparation of a tutorial called "Jingju music: Concepts and Computational Tools for its analysis," in which several members of the CompMusic project took part and that was presented at the 15th International Society for Music Information Retrieval Conference (ISMIR, Taipei, Taiwan, October 27–31, 2014). The slides and code used in the tutorial, as well as recorded videos of a posterior rerun, are available at http://compmusic.upf.edu/jingju-tutorial, including Gulati's presentation on melodic description, where he discusses in detail the performance of predominant melody extraction algorithms for jingju music recordings.

algorithm frequently detects the jinghu line as predominant melody. These problems are not exclusive of jingju music though. In the Carnatic classical music tradition, the voice is closely followed by the accompanying violin, resulting in a similar case of melodic similarity to the one that occurs between voice and jinghu in jingju. To address this problem, Vignesh Ishwar (2014) combines the pitch contour features used in Salamon and Gómez's algorithm, with a timbral model for the voice in Carnatic classical singing, to classify pitch contour candidates into vocal or non vocal, thus improving the results obtained by the state of the art algorithm for this particular music tradition. Sadly, no such an approach was developed for the case of jingju singing.

Since the research object is the vocal melodic line, and the predominant melody extraction algorithms estimate the predominant melody for each frame in the audio recording, the resulting pitch track includes the melodic line of the instrumental sections. Consequently, a step of segmentation between vocal and non vocal passages is required. Chen (2013) implemented a machine learning approach based on the work done by Koduri for Carnatic art music (2012). $Yang_2$ (2014) extended Chen's work with a larger set of features and considering two classes of non vocal segments, namely percussion and melodic sections. $Yang_2$'s approach achieved 85% accuracy for vocal sections (2014: 17), but it was only evaluated in a small dataset of 34 recordings from the JARC, and no study about the scalability of his method for the whole collection was carried out.

In view of the aforementioned difficulties, I concluded that the required preliminary step for the automatic analysis of the JARC in terms of jingju singing did not produce as satisfactory results as I considered for obtaining reliable results in further analysis. At the moment, no member of the team was working in tasks that might improve such results, and even so, the required time for such development would have exceeded the time plan scheduled for the present thesis. Consequently, I decided to change the approach and use symbolic data as the main source for my research. Notwithstanding this, I argue that the creation of the JARC has a great potential for the future research on jingju music. First of all, it is the first large curated collection of jingju audio recordings, documented in detail and carefully organized, and available for research purposes. Even though it was created with the aim of researching traditional jingju singing, studies regarding other aspects of the jingju musical system can be also implemented. Indeed, Srinivasamurthy, in collaboration with other researchers included myself (2014a), studied percussion patterns in a subset of the JARC. Therefore, I argue that the creation of JARC is an important outcome of the research here presented and one of its contributions to the jingju music research. A preliminary study of the potential of the JARC for jingju singing analysis was presented in Caro et al. (2014).

5.2. Jingju Music Scores Collection (JMSC)

The creation of a collection of jingju music scores was already considered in the initial plan for the JMC. Indeed, at the same time as the creation of the JARC, three collections of jingju music scores where purchased, namely the two volumes collection of music scores for selected arias named 《京剧曲谱精选》 *Jingju qupu jingxuan* (Selected jingju music scores, He 2012, Li$_1$ 2012), a 10 volumes collection of music scores for full plays which is frequently mentioned by Zhang$_5$ (1992), the 《京剧曲谱集成》 *Jingju qupu jicheng* (Collection of jingju music scores), compiled by 上海音乐出版社 *Shanghai yinyue chubanshe* (1992–1998), and the 21 volumes that were published at that the moment of purchase of the encyclopedic work 《中国京剧流派剧目集成》 *Zhongguo jingju liupai jumu jicheng* (Collection of plays of Chinese jingju schools, 2006–2010).[10] However, these collections consist in printed editions that are not ready to be used in computational research. Therefore, they were acquired for reference purposes, and for possible uses in future research.

The difficulties observed in the analysis of audio recordings as described previously invited me to explore the possibilities that analysis of machine readable jingju music scores could offer to my research purposes. This approach however necessarily involves the manual creation of such scores. So, I decided to manually create a small dataset of jingju music scores and implement few analyses on them, in order to evaluate if the effort was rewarding. The results of these preliminary analyses[11] were prom-

[10] In a recent visit to NACTA, the manager of the Beijing jingju and kunju store *The pear garden* informed me that the collection already reached the 40 volumes.

ising and informed the research strategy that I followed from that time on, and which resulted in the thesis here presented.

Motivated by the obtained results, I decided to manually create a series of jingju music scores, which now form the JMSC. In the remaining of this section I will describe the collection according to the five criteria already established.

- ***Purpose***: The purpose for the creation of the JMSC is precisely the purpose of this thesis, namely understanding jingju *shengqiang* through the study of its two main representatives, *xipi* and *erhuang*, as expressed in singing. The same requirements described for the creation of the JMC in general, and the already presented JARC in particular, also apply here, namely the focus on arias of traditional plays. Since there was an essential need for minimizing and optimizing the time invested in the creation of the scores, the question arouse about how to chose the most appropriate arias for this purpose.

  During my classes with Shen Pengfei *laoshi*, he suggested the reading of two textbooks that he uses for teaching jingju music composition to his own students in NACTA, namely those by Liu_1 Jidian (1992) and $Zhang_5$ Zhengzhi (1992). These works, as described in Section 2.1, explain each element of the jingju music system by providing examples of selected arias. At the same time, Song Tingting *laoshi* gave me a copy of Cao Baorong's publication (2010). As already described, this work is the result of a class the author used to taught to master students on 京剧声腔概论 *jingju shengqiang gailun*, introduction to jingju *shengqiang*. The classes consisted in letting the students "correctly perform a sample aria score for each *shenqiang* and *banshi* (and each role type)" (2010/1: foreword). Consequently, Cao's work consists in a collection of jingju arias scores, in two volumes, one for *erhuang* and another for *xipi*, in each volume the arias are grouped by *banshi*, and for each *banshi* samples are given for the five role types

[11] This work was presented in the Fourth International Conference on Analytical Approaches to World Music (AAWM 2016). The long abstract and the slides for that presentation are available in http://mtg.upf.edu/node/3511.

for which singing is a defining skill, namely *laosheng*, *jing*, *laodan*, *dan*, and *xiaosheng*.

Regarding the purpose for creating the JMSC, I made the following two assumptions concerning the three references mentioned previously, namely the works by Cao, Liu_1 and $Zhang_5$. They are not only works written by acknowledged specialists within jingju scholarship as result of a lifetime experience of performing, researching and teaching, but they are also referential textbooks in one of the highest level institutions for jingju music teaching and research. Therefore I assume that they are authoritative sources. Secondly, according to the purpose of each of these publications, which is letting the student understand the different elements of the jingju musical system, the arias used as illustration of the explained concepts should have been selected as optimal examples for such concepts. Therefore, I assume that the arias contained in these sources are good representatives of jingju music as it is understood nowadays. I am aware that the cannon of classic arias that represent the jingju musical system resulting from these sources might be biased by the perception of contemporary performers after a complex history of interaction with external musical systems during the 20th century, and also by the practical purpose of these and similar other publications, which is training jingju music composers. However, given the constrains of the current research, and the authoritative and representative nature that I assume for these sources, I concluded that they are a sound reference for the selection of the scores to include in the JMSC according with the purpose here defined.

- ***Coverage***: According to its purpose, and the resulting implications as described previously, the JMSC contains all the arias referenced in the aforementioned three sources for *xipi* and *erhuang*, with the following exceptions. In order to minimize the time invested in the creation of the collection, I decided to consider only the arias for the role types that better represent male and female singing, namely *laosheng* and *dan*. Therefore, arias for other role types have not been included in the collection. Regarding the *banshi*, I have excluded the non metred ones. The main reason for this last decision is technical, since at the moment of the creation of the collection I was not able to find a satisfactory method for notating free metre scores in a machine readable format, that offers the same accuracy and visualization capabilities that the methods available for metred scores. Two final remarks need to be made. Both Cao's and Liu_1's publications contain full scores, however in $Zhang_5$'s work some arias are given in full score, while others are just mentioned by title. In these cases, I searched for these arias in the collections of printed scores mentioned previously, and only eight of these arias have not been found in these collections. Finally, occasionally the same aria is referenced in more than one source. In those cases, I have added all the different editions of the aria to the JMSC, since, on the one hand, each edition presented differences, and on the other hand, I understand that these different editions can be used in a future study about variability in jingju music notation.

Consequently, the 92 music scores contained in the JMSC cover the two main jingju *shengqiang*, *erhuang* and *xipi*, all the main metred *banshi* listed in Table 5, and *laosheng* and *dan* role types, thus encompassing 83 arias from 60 plays. Table 8 gives information about the content of the JMSC in terms of scores. Since each score consists of a complete aria, in some occasions samples of other *banshi* or other role type are also present. Considering this issue, and taking also in mind that arias present a great variability in length, I argue that a more informative quantitative description of the JMSC can be obtained from the number of lines contained, since, as explained in Section 4.2, it is the line the basic structural unit and therefore the main analysis unit. Consequently, and considering only the lines that meet the criteria for the creation of the JMSC, namely *erhuang* and *xipi shengqiang*, metred *banshi* and *laosheng* and *dan* role types, the JMSC covers 899

	ls	*da*	*ls+da*	Total
erhuang	20	17	1	38
xipi	24	27	3	54
Total	44	44	4	92

Table 8. Content of JMSC in terms of scores.
ls stands for *laosheng* and *da* stands for *dan*

	lseh	*lsxp*	*daeh*	*daxp*	Total	*ldeh*
manban	66	17	72	50	205	
sanyan	12	17			29	2
zhongsanyan			6		6	
kuaisanyan	26	6	14		46	
yuanban	112*	47	54	55	268	
erliu				12	12	
liushui		80		121	201	
kuaiban		85		47	132	
Total	216	252	146	285	899	
daoban				1		
sanban	2	3		2		
yaoban	1	8		1		
**kutou*	4					

Table 9. Content of the JMSC in terms of lines.
On the upper heading, *ls* for *laosheng*, *da* stands for *dan*, *ld* for *laodan*, *eh* for *erhuang* and *xp* for *xipi*. Gray background indicates samples of instances not considered for the research presented in this thesis.

lines. Table 9 gives details of the content of the JMSC in terms of lines.

- ***Completeness***: Regarding completeness, two aspects should be considered. Firstly, many of the music scores are provided in the original sources with notation for the accompanying instrumental line. Considering how the instrumental accompaniment is conceived in jingju, as described in Section 4.1, it can be notated in only one melodic line, and according to its relationship with the singing melody, it can be notated even in the same line as the sung melody, as preludes, interludes or fillings during singing rests, separated from the singing melody by brackets and usually marked with a smaller font (Figure 2). To ease the computational processing of the scores in the JMSC, the accompaniment is al-

a. Transnotation of the sample excerpt in Figure 2.a

b. Transnotation of the sample excerpt in Figure 2.b

Figure 6. Transnotation of the examples in Figure 2
as contained in the JMSC.

ways included in a separate staff (Figure 6). In those cases in which singing melody and accompaniment are notated in the same line, the staff for the accompaniment in the JMSC score leaves the sections corresponding to singing as rests (Figure 6.a).

The JMSC is completed with two spreadsheet files for the related metadata, one with information about the scores named `scores_data.csv`, and one with annotations for each line, named `lines_data.csv`. The `score_data.csv` file contains, per each score, its file name, the name of the related work (in Chinese), role type, *shengqiang*, *banshi*, a 'yes' or 'no' regarding if the accompaniment line is complete, that is, is given in a different line in the original source, the reference to the original source

file name	Daxp-ChunQiuTing-SuoLinNang
aria	“春秋亭外风雨暴” ——《锁麟囊》（薛湘灵）
role type	dan
shengqiang	xipi
banshi	erliu; liushui
comp. acc.	no
source	刘吉典《京剧音乐概论》北京：人民音乐出版社，1981；第 397-401 页
MBID	11a44af7-e29a-4c50-aa38-6139d37ca306; 3dcae41a-795c-4b7d-979b-1b52aa42dd3a; 1e705224-0b44-48aa-a0de-6386cda9d517

Table 10. Annotations in the `scores_data.csv` file (example).
`Comp. acc.` stands for complete accompaniment.

(in Chinese), and, if any, the MBID of the related recordings in the JARC (Table 10). Regarding the relationship with the JARC, it should be mentioned that it is not established directly between recording and score, but via the work to which both the recording and the score are related to. This is due to, on the one hand, the very concept of work, as described in Section 4.1, according to which different recordings of the same work might differ with each other not only in the melodic contour, but even in the number of lines sung, and on the other hand, to the fact that music scores in jingju are a posteriori notations of preexisting works, usually with no specific reference to a specific rendition as source. Therefore, it is highly uncommon that the melodic line notated in a particular music score matches with precision the one performed in an audio recording.

The `lines_data.csv` file contains the following information for each line: the role type, the *shengqiang*, the *banshi*, the line type, the lyrics of the line and of each of the line sections, the starting and ending timestamps of the line and of each of the line sections, and the linguistic tones of line’s lyrics (Table 11). The line type indicates if it is an opening line or a closing line. As de-

file name	daxp-ChunQiuTing-SuoLinNang.xml
role type	dan
shengqiang	xipi
banshi	erliu
line type	s
line lyrics	春秋亭外风雨暴,
line start offset	2
line ending offset	14.75
linguistic tones	1124134
S1 lyrics	春秋
S1 start offset	2
S1 ending offset	5.5
S2 lyrics	亭外
S2 start offset	7
S2 ending offset	9.25
S3 lyrics	风雨暴,
S3 start offset	10
S3 ending offset	14.75

Table 11. Annotations in the lines_data.csv file (example).
S1, S2 and S3 respectively stand for the three line sections

scribed in Section 4.4, in the case of *erhuang* there are two different types of opening lines, an extended type and a shorter one that is symmetric to the closing line. Therefore, opening lines are indicated by s (from *shangju*, opening line) in *xipi*, and in *erhuang* by either s1 for the extended type, or s2 for the reduced type, and closing lines are indicated by x (from *xiaju*, closing line) for both *shengqiang*.

The starting and ending timestamps were automatically computed. Firstly, all the lyrics were extracted and automatically grouped into lines according to a conventionalized use of the punctuation.[12] I checked all the results and corrected occasional mistakes. Once the line segmentation was accurate, I used the music21 toolkit to find the first note with which the first syllable of a line is sung, and the last note with which the last syllable is sung, and retrieved what in music21 is called 'offset'. The offset is a numerical value (either a float or a fraction data type) explained as "how many quarter notes it lies from the beginning of the Stream,"[13] where, in this case, 'Stream' refers to the staff for the vocal melody.[14]

The division of lines into their sections was done manually by myself. I could solve dubious cases with the help of Shen Pengfei *laoshi*, especially in those cases in which the line structure was expanded with a *duotou*, or reduced from the usual number of syllables. The general rule given by Shen *laoshi* is that the first and third section of the line always present their original form, and the second section can be extended or suppressed. In certain cases, we checked in the score the rhythmic distribution of the syllables of a section in order to assure that a particular section corresponds to the first or third one. Once the segmentation of all lines was established, their starting and ending timestamps were automatically computed with the same method used for the lines.

Regarding the annotations of the linguistic tones, they consist on a string of numbers, each of which of a value from 1 to 4 for each of the tone categories, or 5 for the neutral tone. These values where computed automatically by the computational linguist Shuo Zhang, collaborator of the CompMusic project, using Native-to-Pinyin, a java utility based on the pinyin4j library.[15] Then they were manually corrected by Gong Rong, a member of the CompMusic team also researching jingju and for whom Chinese

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[12] Generally, opening lines are written ending with comma, and closing lines with full stop. Other marks such as colon, semicolon, exclamation and interrogation marks can also appear signaling a line end.

[13] http://web.mit.edu/music21/doc/usersGuide/usersGuide_04_stream1.html [last accessed]

[14] For example, the first note (or rest) in a staff has an offset value of 0.0, and if the time signature is 4/4, the first two quavers of the second bar have an offset value of respectively 4.0 and 4.5.

[15] https://github.com/zangsir/Native-to-Pinyin

is his mother language, and myself. Dubious cases were solved with the help of Xiong Luxia *laoshi*.

- ***Quality***: Since one of the CompMusic project's basic guidelines is addressing the cultural specificity of each of the music traditions researched, my first approach was to use software that supports *jianpu* notation. A second important criterion was that this software should allow to export the music score in MusicXML format. In the CompMusic project we concluded that this would be the most convenient standard for machine readable music notation, given its wide use and that it is supported by most of the music score processing software. After researching the programs available in the market,[16] I decided to use 美得理简谱软件 Medeli *jianpu* software v2.0,[17] which meets these two criteria, and in fact the first dataset of music scores used for the preliminary research previously mentioned[18] was created with this software. However, it presents several problems when exporting to MusicXML. Firstly, it only supports MusicXML 2.0, whilst the current common version is MusicXML 3.0. Independently of the declared key signature, number 1 was always associated to C4, and the remaining degrees in relationship to this. This implies that the notes of each score should be transposed to match the established key before being processed for analysis. Duration values shorter than the demisemiquaver where stored as demisemiquavers. Finally, slurs and some ornaments where stored in a way that was later not recognized or recognized with errors when loaded to music21. As a consequence, and considering that *jianpu* notation and staff notation share most of their principles and that transnotation from one system to another is straightforward, I decided to use a program for editing scores in staff notation.[19]

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[16] I thank Yang Yile for his collaboration in this task.

[17] http://www.medeli.com.cn/index.php/html_info/musicsoft/

[18] See footnote 11.

[19] Before ceasing to use Medeli, the original dataset of scores was extended and used in the experiments presented in Gong et al. (2016).

The program selected for creating the scores is MuseScore[20] (v2.1.0). The main reasons for selecting this software are that, being open source, it aligns with the general philosophy of the MTG of promoting open content and open source programs, it supports all the notation needs from the sources, it exports in MusicXML 3.0, and it is fully compatible with music21—in fact, its website suggest that it "is highly recommended for working with music21." [21] Consequently, the JMSC contains music scores in both MusicXML and the original MuseScore own format, MSCZ.

As already mentioned, transnotation between *jianpu* and staff notation is straightforward, so the music scores in the JMSC reproduces all the information existing in the originals. The change of notation system only posed two problems for which I had to make decisions. Firstly, the original sources do not specify any key signature, since, as explained in Section 4.1, actual tuning is adjusted, within a certain range, to the needs of the performer. The only exception is $Zhang_5$'s work, in which the scores do specify the key signature. Secondly, *jianpu* has not a unified standard for determining the octave to which number 1, and from it the remaining degrees, is associated. Regarding the key signature, according to the purpose of the JMSC and the methodology proposed, I decided to edit all the scores in the same key signature, in order to facilitate comparative analysis. This would mean that in some cases I had to replace the original key signature given by $Zhang_5$. In the introduction to each *shengqiang*, both $Zhang_5$ and Cao discuss frequent key signatures for notating *laosheng* and *dan*. $Zhang_5$ (1992) argues that in *erhuang*, the common key used for *laosheng* is E, and D for *dan* (32). In *xipi*, the author points out E for both *laosheng* and *dan* (446). Cao gives several options for each case: E or F for *laosheng* and D, E♭ or E for *dan* in *erhuang* (2010/1: 2), and E or F for both *laosheng* and *dan* in *xipi* (2010/2: 1). Consequently, the key that is most commonly mentioned by both authors for the two role types and two *shengqiang* is E, and this is the key used in all the scores. Regarding the abso-

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[20] https://musescore.org

[21] http://web.mit.edu/music21/doc/installing/installAdditional.html

lute pitch, in preliminary studies I measured the absolute pitch of some audio recordings from the JARC, and found that the first degree is located close to E4.[22] Therefore, I used this pitch as the equivalent to number 1 in the original sources.

Even though I always sought to reproduce the original score as faithful as possible in every aspect, in some special occasions I introduced some changes. Most of them are related to punctuation in the lyrics, in order to ease the automatic line segmentation of the lyrics as described above, or enclosing padding syllables within brackets, to be ignored for the analysis of linguistic tones. In some scores for *dan*, I transposed the original notation an octave higher, so that the first degree correspond to E4. Finally, if the convention for notating *dan xipi yuanban* is using a 4/4 time signature, the only score provided by $Zhang_5$ as example of this class of aria (1992: 480–481) is notated using a 2/4 time signature. In order to homogenize all the related scores, I edited this score in 4/4 and doubled the duration value of each note.

- ***Reusability***: As with the case of the JARC, all the scores contained in the JMSC reproduce copyrighted sources, and therefore can not be publicly shared. However, they are available to scholars who wish to access them for research purposes. The two metadata files however are openly accessible. More detailed information in the thesis' companion web page.

The potential of the JMSC to fulfill the purpose for which it was created is reflected in the results of the present thesis. However, I argue that the coverage of the collection and the completeness of the related metadata makes this collection a valuable resource for other research tasks. One interesting task, that is closely related to the purpose for which the JMSC was created, is pattern discovery and similarity analysis, a task that has found an important development within the MIR discipline, with different proposals for music representation, pattern finding methods and similarity measures.[23] The annotations contained in the metadata files can be used for developing culture specific heuristics that inform this or other

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[22] These measurements have been only partially published in Caro et al. (2014). It can also be tested in the jingju section of the Dunya website (http://dunya.compmusic.upf.edu/jingju/).

analytic tasks. The scores can be used in combination with audio recordings for the research of jingju performance, or as support to the analysis of audio recordings. In fact, the latter has been already implemented by CompMusic researchers, who used the JMSC[24] to improve the segmentation of jingju audio recordings into syllabic units (Gong et al. 2016, 2017a, 2017b, Pons et al. 2017b). The presence of a staff for the accompaniment line, even though not in all cases is complete, offers an interesting opportunity for the analysis of the jinghu line in its own, or its relationship with the singing melody. Finally, the JMSC shows great potential for the study of jingju lyrics, since they are contained in the scores and annotated in the metadata files, both in terms of their structure and the linguistic tones. The ease with with analyses of these elements can be implemented, and the novelty they represent in terms of methodology, encouraged me to indeed carry out a preliminary study of the latter of these aspects. I considered the obtained outcome meaningful enough as to be presented along this thesis, as I do in Chapter 6.

So far I have presented the JARC and the JMSC, two collections in whose creation I was directly and mainly involved. In the remaining of this chapter I present the other two collections that complete the JMC. Even though I was only partially or indirectly involved in their creation, I briefly describe them here in order to offer a comprehensive overview of the JMC. At the end of the chapter, I also introduce the test datasets built for jingju music research, and therefore related to the JMC, in some of which I was only indirectly involved. My aim is to offer a general description of the JMC in its broadest scope, so that it can be taken as reference for reuse in future research.

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[23] For an overview of state of the art approaches that can be used with the JMSC, please refer to Janssen et al. (2013).

[24] For this specific task, besides the JMSC, I created eight new scores that were required for the authors. I did not add these scores to the JMSC for two main reasons. Firstly, they do not comply with the criteria stated in the purpose for the creation of the JMSC, inasmuch as they are not mentioned in the reference sources and four of them use different *shengqiang*, such as *nanbangzi* and *sipingdiao*. Secondly, the corresponding metadata only contain the information required for this specific task, and therefore are not as complete as those for the JMSC. However, they might be considered for a future expansion of the JMSC.

5.3. Jingju Lyrics Collection (JLC)

The study of lyrics, being an essential part of sung music traditions, has been considered an important research object in the CompMusic project, especially in the case of jingju. To approach this issue, we counted with the collaboration of Shuo Zhang$_1$, a computational linguist and Chinese native speaker. We first collaborated in the research of the relationship between the linguistic tones and the vocal melody in audio recordings (Zhang$_1$ et al. 2014, 2015), but then we saw that there were opportunities for researching the content of the lyrics in relation with the musical system from a Natural Language Processing (NLP) point of view. To that aim, the first step was gathering a collection of jingju lyrics. Since the lyrics should be in a machine readable format, so that they can be analysed automatically, we decided that the best source from where to build the collection was the website 中国京剧戏考 *Zhongguo jingju xikao* (Theatrical study of Chinese jingju),[25] to which I will refer as Xikao. Its founder, known by the nickname 小豆子 *xiao douzi*,[26] created this website with the aim of digitizing a collection of 2147 printed scripts.[27] This task has been carried out by *xiao douzi* and other 280 collaborators who generously contributed to this vast project. Since Xikao offers the scripts copyright free,[28] we decided to scrap this website in order to build the Jingju Lyrics Collection (JLC) to be included in the JMC. After agreeing in the purpose of the collection, the scrapping process of Xikao and the post-processing of text in order to obtain structured data was implemented by Shuo Zhang. The JLC was first presented by Zhang$_1$ et al. (2017).

- ***Purpose***: As described in Sections 4.4 and 4.5, when arranging music for a new play, *shengqiang* and *banshi* are selected according to the content of the lyrics. The purpose for creating the JLC was precisely to carry out such study.

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[25] http://www.xikao.com/

[26] Interestingly, this is the nickname of the starring character 程蝶衣 *Cheng Dieyi* from the acclaimed film 《霸王别姬》*Bawang bie ji, Farewell my Concubine*, directed by 陈凯歌 Chen Kaige.

[27] http://scripts.xikao.com/list/comprehensive

[28] http://scripts.xikao.com/copyleft [last accessed]. We also contacted *xiao douzi*, who granted us permission for using the Xikao repository of scripts.

- ***Coverage***: At the moment of creating the JLC, Xikao had already digitized 1086 scripts, covering 850 plays. According to the aforementioned purpose, only lyrics from arias were included in the JLC, and the remaining text was discarded. The lyrics of the arias were then segmented into lines, which are considered the analysis unit also for this collection.
- ***Completeness***: Regarding the collection's purpose, each lyrics line is annotated with the *shengqiang* and the *banshi*. Consequently, information about role type has not been included.
- ***Quality***: The scripts in Xikao were not conceived for its computational analysis, but for human reading. Therefore, directions regarding the intervening character, declamation, *shengqiang*, *banshi*, etc., are inserted within the text file. Consequently, the files scrapped from Xikao contain too much noise for their computational exploitation in terms of the proposed purpose and method. Therefore, Zhang_1 carried out a pre-processing method based on NLP methods, consisting in the following steps:
    - extraction of the lyrics lines of only the arias (discarding text for declamation), and the corresponding information about *shengqiang* and *banshi*,
    - word segmentation using the Conditional Random Field-based Stanford Word Segmenter (Teng et al. 2005), whose results were verified manually and deemed reasonable,
    - Unicode based tokenization,
    - and removal of punctuation and 125 frequent monosyllabic words from a standard stop word list for Chinese language.
- ***Reusability***: The JLC is openly available for future use. The details are available in the thesis' companion web page.

5.4. Jingju *a Cappella* Recordings Collection (JaCRC)

The Jingju *a Cappella* Recordings Collection (JaCRC) is the last one to be created for the JMC, and is still growing. The main contributor to the collection is a member of the CompMusic project, Gong Rong, who is building this collection as main source for his doctoral research (Section

2.2). At the time of writing the collection is divided in two parts, which will be presented here.[29]

- ***Purpose***: Due to the limitations that the work with the recordings from the JARC presented, as observed in the preliminary study already mentioned, and in which I counted with Gong's collaboration, we decided to test the same methods with *a cappella* recordings. Therefore, the initial purpose for creating the JaCRC was the same as the one for the JARC. After a search for existing collections, we only found the SVAD, gathered by Black et al. (2014) that is luckily accessible on the web. However, the number of recordings was too reduced for our goals (see Table 1). Producing new recordings in our research context, Barcelona, is really difficult for the lack of jingju performers in the country. At the same time, I had found the benefits of using music scores for my own research, and decided to focus on this data source.

  However, Gong's research heavily relies on audio recordings.[30] His goal is to develop tools for aiding jingju singing teaching. His proposed method consists in measuring the similarity between the recorded singing of the user and a reference recording from a teacher. For the development of similarity metrics, Gong is drawing on machine learning methods, which demand a great number of training data. Therefore, he has devoted a great effort in expanding the collection in order to carry out his research. Consequently, the current purpose of the JaCRC is the research of the similarity between two jingju singing recordings, of which one is taken as a reference ('teacher') and the other as a candidate ('student').

  During his fieldwork in NACTA, Gong realised that an essential aspect in jingju singing learning is achieving an accurate pronunciation. Therefore, assessing similarity in terms of pronunciation is the central aspect of Gong's research (Pons et al. 2017a).

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[29] A third part has been recently created by Gong, and is currently in the process of being published. At that time, it will be also announce in the CompMuic website for test datasets (http://compmusic.upf.edu/datasets).

[30] The information in the following two paragraphs was learnt from personal communications with Gong Rong.

A necessary preliminary step for this task is the automatic segmentation of the recording into syllabic units (Gong et al. 2017a). These two factors have also informed the content of the JaCRC metadata and the corresponding annotations.

The two parts of the JaCRC, to which I will respectively refer as JaCRC-1 and JaCRC-2, were created with different approaches and in different circumstances. Therefore hereunder I will briefly described the two of them separately.

- ***Coverage***: The JaCRC-1 contains 67 recordings, 28 for *laosheng* and 39 for *dan*. The recordings in JaCRC-2 belong to professional and amateur performers, and are so labeled. Therefore, the collection contains 113 recordings of professional performers and 46 recordings of amateur performers, in both cases covering the role types *laosheng*, *dan* and *jing*. The recordings in the JaCRC-2 have been segmented into lines, covering 863 singing lines from recordings of professional performers, and 575 singing lines from recordings of amateur performers. An interesting and valuable content of the JaCRC-2 is a set of 69 recordings of live jinghu accompaniment, played in a different room and to which the actor or actress listened with headphones. Even though *shengqiang* and *banshi* are not relevant information according to the collection's purpose, the annotations show that the JaCRC covers *erhuang*, *xipi*, *nanbangzi* and *sipingdiao*. About *banshi*, the annotations are not complete.
- ***Completeness***: The JaCRC-1 is accompanied by two spreadsheet files, one for *dan* and another for *laosheng*, containing information about the work performed in each recording and whether it is annotated in terms of phonetic segmentation. For those that are annotated, the annotations, made with the software Praat, are also provided in a textgrid file for each recording, covering 27 *dan* recordings and 23 *laosheng recordings*. The annotations contain boundaries to the line, syllable and phoneme levels. The JaCRC-2 is accompanied by two spreadsheet files. The first one contains metadata and annotations per recording, including the performed work, role type, *shengqiang*, *banshi*, if there is a recording for the

jinghu accompaniment, the affiliation of the performer, the performer's name and his or her professional level. The second file contains metadata and annotations per line, including role type, *shengqiang*, *banshi*, line type (Section 5.2), lyrics per line, and if applicable, the name of a related music score from the JMSC, the lyrics from the corresponding line in the score, and the starting and ending timestamps of the corresponding line in the score.

- ***Quality***: The JaCRC-1 contains recordings from four different sources:
  - the jingju recordings included in the SVAD collection gathered by Black et al. (2014),
  - recordings of two jingju amateur performers from the UK-Chinese Opera Association done by myself in a classroom with a Sony PCM-D50 hand recorder,
  - recordings of four amateur performers from the UK-Chinese Opera Association done in the recording studios at the UPF by Gong Rong, Oriol Romaní Picas (technician) and myself,
  - clean singing tracks obtained from subtracting the accompaniment track provided in some commercial releases from the track that mixes it with a singing track.

  The recordings contained in the JaCRC-2 were made by Gong Rong in two different recording setups. For a detailed description of the technical settings, please refer to Gong et al. (2017c).

- ***Reusability***: All the recordings, metadata and annotations are available for future use. More details in the thesis' companion web page.

The JaCRC is the first completely openly available collection of *a cappella* jingju singing recordings, so far containing 180 files of *laosheng*, *dan*, and *jing* role types, covering four different *shengqiang*. The fact that there is no instrumental accompaniment simplifies the process of extracting the melodic outline, with a great level of accuracy. This opens up a wide variety of possibilities for research beyond the tasks for which the collection was created. The most interesting ones from a musicological point of view is the study of the performance style, including the characterization of role types in terms of melodic complexity, articulation, expressivity through loudness and timbral variations, etc. The jinghu recordings that accompany many of the singing recordings allow interesting studies of either the relationship between voice and jinghu, or jinghu performance by itself. Finally, the JaCRC contains recordings by male and female *laosheng* performers, male and female *dan* performers and male and female *jing* performers, thus offering an excellent opportunity for the research of the timbral qualities, and other characteristics of transgender performers.

5.5. Test-datasets related to jingju music

For the implementation of specific research tasks related to jingju music, different test datasets[31] were created, either from data from the JMC, or with new data gathered especially for a particular tasks. Even though my participation in their creation was in occasions just as consultant, I will briefly present them all hereunder in order to give a complete overview of the data gathered in the CompMusic project for jingju music research, and which complement the JMC. If not otherwise specified, my involvement in the creation of these datasets was at least contributing to the design and planning of the related research tasks.

- ***Beijing Opera Percussion Instrument Dataset***.[32] This dataset and the following task were created for a study of jingju percussion patterns carried out by Mi Tian and Ajay Srinivasamurthy. For this goal, the first task consists in detecting the onset of each instrument, and this dataset was created for this aim. It contains 236 audio recordings of single strokes of the five percussion instruments from the accompaniment ensemble, namely danpigu, ban, daluo, xiaoluo and naobo. The recordings were made by Mi Tian in a studio at the C4DM, and used as a training dataset for the onset detection algorithm (Tian et al. 2014a).
- ***Beijing Opera Percussion Pattern Dataset***.[33] The second task related to the study of jingju percussion patterns consisted in their automatic transcription and recognition, for which this training

[31] A description of each dataset and indications about how to get the data are available at http://compmusic.upf.edu/datasets.

[32] http://compmusic.upf.edu/bo-perc-dataset

[33] http://compmusic.upf.edu/bopp-dataset

dataset was created. For its creation, we selected the *Jingju zhi xing* collection of 30 commercial CDs from the JARC. I manually annotated all the percussion patterns used for introducing the recorded arias, and we selected the five most frequent ones, namely *daobantou*, *man changchui*, *duotou*, xiaoluo *duotou*, and *shanchui*. The dataset hence contains all the fragments extracted from the CDs containing a sample of these patterns, summing 133 recordings. Each sample is labeled with its corresponding pattern and annotated with a syllabic transcription of the pattern obtained from corresponding literature.

- ***Annotated jingju arias dataset***.[34] This dataset contains annotations for 34 recordings from the JARC created by myself. They cover the *laosheng*, *jing*, *laodan*, *dan*, and *xiaosheng* role types and the *xipi* and *erhuang shengqiang*. The annotations are stored as Praat TextGrid files, and contain two types of information. Firstly, they contain metadata about the recording, including the recorded work, its MBID, the name of the artist, the singing school to which he or she belongs—if specifically stated in the release metadata—and his or her role type. Secondly, they contain timestamps from the segmentation of the recording in terms of *shengqiang*, *banshi*, lines, syllables and percussion patterns. The dataset groups and unifies annotations from data used for different tasks (Zhang$_1$ et al. 2014, 2015; Yang$_2$ 2016).
- ***Jinju* A Cappella *Singing Pitch Contour Dataset***.[35] This dataset contains the pitch track and annotations for 39 recordings from the JaCRC-1. The annotations consists of segmentation points of the pitch track into three different categories, namely steady, vibrato and transitory, and were created manually. They were used as training dataset and ground truth annotations for the task of automatically segmenting jingju *a cappella* singing recordings into these three categories (Gong et al. 2016).

[34] http://compmusic.upf.edu/node/349

[35] https://doi.org/10.5281/zenodo.832735

- ***Jinju* A Cappella *Singing Audio and Boundary Annotation Dataset*.**[36] This dataset contains annotations for 65 recordings from the JaCRC-1 stored as Praat TextGrid files. They consist in the segmentation of the recording in different linguistic levels, such as line, syllable and phoneme, the first two annotated with the pinyin romanization of the lyrics, and the third level with X-SAMPA symbols for phoneme. The annotations were done manually by two researchers of jingju music whose mother tongue is Chinese and myself. The dataset was used for different tasks related to phonetic analysis of jingju singing recordings (Gong et al. 2017b, Pons et al. 2017a).

5.6. Conclusions

The JMC created in the CompMusic project for the research of jingju music from a computational approach is to date the largest corpus gathered for such purpose. An important characteristic is that, except for copyrighted data—for whose access detailed information is provided in the thesis' companion web page—all the contents of the corpus are openly available to the research communities. The four collections of data types, and the corresponding annotations, make this corpus also the most exhaustive for the research of jingju music. Regarding music scores and lyrics, there are printed publications that cover a much larger repertoire than respectively the JMSC and JLC. However, it has to be noted that the purpose for the creation of the JMC is to gather data for the study of jingju music through computational methodologies. Therefore, these two collections, the JMSC and the JLC, do contain the largest quantity of machine readable data required for such approaches. On the other hand, the still growing JaCRC arguably is one of the most original and therefore relevant contributions of the JMC, since no *a capella* recordings of jingju singing—as well as of jinghu solos—in the quantity of this collection had been gathered and made completely available for research purposes. Even though the creation of the JMC is the result of a collective effort by members of the CompMusic project, an important workload of the doctoral research here presented was invested in contributing to this creation, espe-

[36] https://github.com/MTG/jingjuPhonemeAnnotation

cially in the JARC and the JMSC, the latter created uniquely by myself with the main goal of addressing this thesis' objectives. Consequently, I consider my contributions to the JMC one of the most relevant outcomes of my doctoral research.

Chapter 6 Relationship between linguistic tones and melody[1]

That linguistic tones affect the sung melody in jingju arias is a universal assumption among jingju music scholars. However, the nature of this relationship has not been definitely established in the state of the art literature. Section 4.2 discusses in detail the difficulties for reaching a general agreement, as well as the different relationships that authors use for explaining the influence of linguistic tones on the sung melody. As a result, I established three relationship types, namely syllabic contour, which considers the relation between the tonal contour of one syllable and the melodic contour used for singing it, first-first pairwise relationship, which looks at the relationship in terms of pitch height between the first notes of two consecutive syllables, and last-first pairwise relationship, similar to the previous one, but considering the last note of one syllable and the first note of the following one.

When reflecting upon the reasons that caused that after almost one century of research on this topic a general agreement is still to be reached, Xu_2 argues that “the majority of authors obtained their understanding of linguistic tones in jingju through their personal experience, and this experience in its majority was obtained by listening or imitating” (2007: 49). Taking this argument into consideration, the data and methodology proposed for this thesis could contribute to this topic with an empirical approach which provides statistical data. The JMSC is annotated with linguistic tone information for all the contained lyrics (Section 5.2), which

[1] Preliminary results of this study were published in Caro and Serra (2017).

can be used to map their melodic realisation as notated in the machine readable score.[2] In order to exploit this potential then, I wrote a piece of code to extract statistics about the three considered relationship types between linguistic tones and melodic contour. The aim of this code, besides providing data for this thesis, is offering an openly available tool for researchers interested in using it—accessible in the thesis' companion web page. Therefore, in the next section I describe in detail the functionalities of the code, and how to be used. In the remainder of the chapter I present and discuss the obtained results and conclude with the expected contributions to the studied topic, and its influence for the melodic analysis presented in Chapter 7.

6.1. Description of the code

In order to exploit the JMSC and the tone related annotations with the aim of contributing to the understanding of the relationship between melody and linguistic tones in jingju singing, I wrote a piece of code which comprises two main functions plus a series of auxiliary ones. Each of the main functions is related to the two main relationships between linguistic tones and melody, namely syllabic contour and pairwise relationship, the latter specified into its two types, first-first and last-first. In the following sections I will describe these two functions in order to clarify how the statistics about the relationships are obtained.

Syllabic contour

Yu Huiyong classifies the syllabic contours into five categories, namely Level (`L`), Ascending (`A`), Descending (`D`) or a combination of the last two ones, namely Ascending-Descending (`AD`) and Descending-Ascending (`DA`) (2008: 19). When a syllable is notated with one single syllable, I assigned to it by default the Level category (`dL`). The goal of the **`syllabicContour`** function is to compute statistics about the occurrence

[2] Previously to this analysis on symbolic data, this issue was addressed from audio sources. With the collaboration of Shuo $Zhang_1$, we studied both the syllabic contour ($Zhang_1$ et al. 2014) and the pairwise relationship ($Zhang_1$ et al. 2015). However, due to the technical difficulties this task implies, and even though interesting insights were obtained, we did not reach results that from a musicological point of view were fully satisfactory for me.

of each of these six contour classes, which are represented by the abbreviated forms given in brackets, for each tone category. The auxiliary function **`toneMaterialPerLine`** takes as parameters, on the one hand, the path to the `lines_data.csv` file included in the JMSC which contains the annotations per line, and on the other hand a list per each of the four elements of the jingju musical system, namely role type, *shengqiang*, *banshi* and line type, with the instances of these elements that should be considered. These last four parameters are given by default all the possibilities appearing in the JMSC for each element, so that if a list is not input for any of these elements, all the instances will be considered. The function returns a new list with the data required for the analysis of syllabic contour from the lines that met the input instances.

The **`syllabicContour`** function takes as only required parameter the resulting list from the **`toneMaterialPerLine`** function. With that information, first, the lyrics for each of the line to be analysed are linked with their tonal category. For the classification of the syllabic contour into one of the six previously described categories, a list containing the midi values of the notes of each syllable's melodic contour is fed to the auxiliary function **`defineContour`**, which returns one of the six labels. To assign a label, if the input syllabic contour contains only one note, it is automatically assigned to `dL`. If the syllabic contour comprises two notes, the `L` label is assigned if both of them share the same midi value, the `A` label is assigned if the midi value of the first note is lower than the one of the second note, and the `D` value is assigned if the midi value of the first note is higher than the one of the second note. If the syllabic contour is formed by three or more notes, if all the midi values of the central notes lie within the range formed by the midi values of the first and last notes, the label is assigned as in the previous case considering only these two notes. Otherwise, if the midi value of one or several notes lies beyond that central range, the note whose absolute distance from this range is the largest is identified. If its midi value is lower than the lowest value in the central range, the `DA` label is assigned. Otherwise, if its midi value is higher than the highest value in the central range, the assigned label is `AD`. The returned syllabic contour label is then associated with the tone category of the corresponding syllable.

In many occasions, especially at the end of a line section, a syllable can be performed with a melismatic expansion called *tuoqiang*. Taking into account that, according to some authors, the tonal information is expressed at the beginning of the syllabic contour, it seems unlikely that the melodic contour of the whole *tuoqiang* is related to the linguistic tone. In order to avoid assigning a syllabic contour label to a *tuoqiang*, the **`syllabicContour`** function establishes a length threshold, so that for those syllabic contours that surpass it, only the first three notes are considered. This threshold is specified for each combination of the instances of role type, *shengqiang* and *banshi* contained in the JMSC. To establish its value in each case, a melodic density analysis is performed for each combination using the **`melodicDensity`** function (described in Section 7.2) taking the aggregated duration of the contour, measured in crotchets, as value. The average upper fence of the box plot that results from this function is taken as threshold for discriminating a *tuoqiang*. As a result, the occurrence of each syllabic contour category per tone category is counted, both in absolute values and percentage of the total (see Table 12). If a path for a file is input to the optional parameter `filename`, the resulting values are returned as a tab separated values (`tsv`) file. Otherwise, they are just printed on the console.

The **`syllabicContour`** function has an extra functionality. It allows searching for characters belonging to a specific tone category that are realised with a specific syllabic contour category. To use this functionality, a list containing the tone number and the syllabic contour category label should be input to the default parameter `query`. The function will open those scores in which the given combination of tone and syllabic contour categories are found, with the notes of the corresponding melodic contour colored in red. More details about this functionality and the function in general are available in the documentation of the code.

Pairwise relationship

In order to study the pairwise relationship between consecutive syllables, I borrow the categories used for the syllabic contour analysis. In this case, what is analysed is the relationship between either the first or last note of the first syllable in a pair, with the first note of the second syllable of the pair. This relationship can be classified into three categories, Level (`L`) if both notes share the same pitch, Ascending (`A`) if the first note has a lower pitch than the second, and Descending (`D`) if the first note has a higher pitch than the second. Assigning one of the labels to each pair of consecutive sung syllables is the goal of the **`pairwiseRelationship`** function. As input, this function takes the resulting list from the auxiliary function **`toneMaterialPerJudou`**, which is identical to the already described **`toneMaterialPerLine`** function, with the only difference that it retrieves information per line section, and not per line. This distinction is required because line sections are usually separated between them by a rest filled with an instrumental interlude or filler (Section 4.2). In this case, the last syllable of a section and the first one of the following section would not be perceived as a pair, and therefore the rules for the pairwise relationship between these two syllables might not apply. The default parameter `relationship` takes a two elements list indicating which note of syllabic contour for respectively the first and second syllables of the pair should be considered, either the first note, selected by inputting `0` in the list, or the last note, marked by `1`. Therefore, inputting `[0, 0]` to this parameter would sets the function to compute the first-first pairwise relationship, while inputting `[1, 0]` allows computing the last-first relationship, which is established as a default option for this parameter. In order to assign one of the three labels to each syllable pair, the function compares the midi value of the selected note from each syllable, and assigns `L` if they both share the same value, `A` if the first note's value is lower than the second note's, and `D` if the first note's value is higher than the second note's. The function counts the occurrence of each of these contours for all the possible pairs of tone categories. Since the neutral tone is also annotated in the JMSC as 5, this tone category is also considered in the **`pairwiseRelationship`** function, resulting in 24 tone categories pairs (the only pair that is not included is 55, for which there are no examples in the JMSC). As in the case of the **`syllabicContour`** function, the results are given as absolute count or as a percentage of the total. These results are printed on the console and, if a file path is given as to the optional parameter `filename`, also saved as a `tsv` file. Finally, this function also contains a `query` parameter, which takes a two elements list as input, namely a specific pair of tone categories and a syllabic contour label. If such a list is input, the function opens through music21 the score of the line section that contains a syllabic pair that meets the given search terms.

An important remark should be done regarding the two functions just described. When a score is parsed by music21, the grace notes are processed as notes with no length and sharing the same offset position as the following main note. The `note` class in music21 is equipped with a `priority` attribute, which in the case of grace notes can be used to establish its position before (with negative integers) or after (with positive integers) the main note. However, the MusicXML version of the scores created with MuseScore did not assign a value to the `priority` attribute, which keeps its default value 0. Therefore, it is not possible to find out if a given grace note is tied to the following or the previous main note, or even which is the order in a group of grace notes. Consequently, by default, the grace notes that are tied to the previous main note will be considered as tied to the following one, then potentially affecting the overall syllabic contour of both the previous and following main notes. Consequently, and conscious that this step introduces some noise in the obtained results, both the **`syllabicContour`** and the **`pairwiseRelationship`** functions skip grace notes for the assignment of the corresponding labels.

According to the CompMusic's project commitment with reproducibility, besides the general script here described, there are two extra scripts available for each of the two main analysis tasks, **`jTA_syllabic_contour`** and **`jTA_pairwise_relationship`**, respectively for the analysis of syllabic contours and the pairwise relationship. These scripts allow to obtain the results presented in the following sections by using a single command line. Furthermore, they will permit those researchers interested in this task to benefit from both the JMSC and the code according to their own personal needs.

6.2. Syllabic Contour Analysis

For the analysis of syllabic contour I used the **`syllabicContour`** function on the whole JMSC, therefore obtaining the broadest view possible. The obtained results are shown in Table 12, covering 7,283 syllabic

	Tone 1 (1645)	Tone 2 (1724)	Tone 3 (1516)	Tone 4 (2252)	Tone 5 (146)
dL	699 (42.49%)	511 (29.64%)	522 (34.43%)	664 (29.48%)	
L	156 (9.48%) (16.49%)	98 (5.68%) (8.08%)	81 (5.34%) (8.15%)	139 (6.17%) (8.75%)	
A	110 (6.69%) (11.63 %)	**458** **(26.57%)** **(37.76%)**	281 (18.54%) (28.27%)	**665** **(29.53%)** **(41.88%)**	
D	**471** **(28.63%)** **(49.79%)**	338 (19.61%) (27.86%)	**368** **(24.27%)** **(37.02)**	326 (14.48%) (20.53%)	
AD	112 (6.81%) (11.84%)	192 (11.14%) (15.83%)	146 (9.63%) (14.69%)	269 (11.94%) (16.94%)	
DA	97 (5.9%) (10.25%)	127 (7.37%) (10.47%)	118 (7.78%) (11.87%)	189 (8.39%) (11.9%)	

Table 12. Results for the syllabic contour analysis.
In brackets, first, overall percentage, then, percentage after subtracting the instances classified as dL.

contours. The table also gives information about the total number of syllabic contours per tone category. Even though the neutral tone is annotated in the JMSC, and therefore parsed by the function, I do not compute statistics for it since linguistically it does not own a tonal contour of its own, but it depends on the preceding syllable, it is usually not discussed in the literature about melody and linguistic tones relationship, and it stands for a very small percentage of the total syllabic contours (just a 2%).

The first noticeable information obtained from these results is the fact that dL is the most frequent syllabic contour for all tone categories. The explanation might be found in a factor that is not directly related to tonal contour and melody relationship. More than a third of the analysed lines (37.04%, Table 15) belong to *liushui* and *kuaiban*, two *banshi* which, due to their characteristic fast tempo, present a very syllabic singing style, implying that most syllables, regardless of their tonal category, are sung with just one note. In this case, the tonal information of the lyrics might be conveyed through the pairwise relationship. Consequently, the results for `dL` are not representative for the analysis of syllabic contours. Because of this reason, the percentages given in Table 12 for the rest of syllabic contours are given for the overall count, but also after subtracting from that total count the number of `dL` labels. The most remarkable observation about the results for `dL` is that in tone 1 they stand for a much higher percentage than for the other tones. This is an indication that this syllabic contour is commonly used for tone 1 even in other *banshi* than *liushui* and *kuaiban*, stressing a tendency to prefer level syllabic contour.

The least used syllabic contour across tone categories is `L`, what points to a preference for melodic dynamism in the singing of single syllables. The major use of this syllabic contour is present in tone 1, confirming the preference for this contour observed in the results for `dL`. However, regarding tone 1, the most frequent syllabic contour by far is `D`, standing for almost half of the realisations. This fact should not be taken as a contradiction of the preference for level contours previously observed. As discussed in Section 4.2, some authors characterize tone 1's syllabic contour as slightly descending (Yu 2008: 22, Zhang_4 2011: 54). Since the results do not give any information about the overall shape of the melodic contour, it could refer to mostly level ones with a slight descending inflection at the end.

The syllabic contours `AD` and `DA` present also a low percentage of use across tones. A similar explanation to the one for the higher use of `dL` can be suggested here, arguing that syllabic contours of three or more notes are a minority, especially used in slow tempo *banshi*, such as *manban*, *sanyan*, *zhongsanyan* and *kuaisanyan* (which stand for a 31.81% of the total lines). Therefore, the opportunities for realizing such contours are more limited than for the others. The most frequent syllabic contours in general are `A` and `D`. The former is the most frequent syllabic contour for both tones 2 and 4, while the latter is the most frequent one for tone 3. Comparing these results with the tonal contours generally assumed for the four tonal categories in BJ and HG (see Table 3), it seems that they aligned better with the tonal contours of HG. Notwithstanding this, the use of the opposite syllabic contours for these three tones is significant, indicating a high degree of variability in the sung realisation of tones 2, 3 and 4.

6.3. Pairwise relationship analysis

Tables 13 and 14 show the result of the analysis of the pairwise relationship for 5,494 pairs of consecutive syllables. The former presents the results for the last-first pairwise relationship, while the latter presents the results for the first-first pairwise relationship, and both these results were computed using the **`pairwiseRelationship`** function for the whole JMSC. As in the previous section, both tables include results for pairs involving the neutral tone, or tone 5. However, for the same reasons stated in the previous sections (in this case, the pairs containing tone 5 stand for a 3.64% of the total number of pairs), in the discussion of the results here presented the pairs involving tone 5 will not be addressed.

An interesting observation from the comparison of both tables in terms of which is the most frequent relationship type, that is, the label with highest percentage, for each syllables pair is that it is the same in both of them, with the only exception of the 1-1 and 4-2 pairs (and excluding those pairs including tone 5). Furthermore, when the same relationship is preferred in both last-first and first-first cases, its occurrence in the latter case shows a higher percentage than in the former one. These observations might point out that, firstly, the pairwise relationship is generally related to the overall syllabic contour, rather than focused on its initial or final notes. It has to be noted that, as the syllabic contour analysis suggested, a third of the syllables are performed with a single note, and that syllabic contours of three or more syllables are a minority. Secondly, since the results for first-first relationship show higher percentages for the most frequent relationship type in most of the syllables pairs, it could be argued that first-first relationships express the preferred relationship type with more clarity than their last-first analogues, although this assertion is more nuanced, as it will be discussed below. As a final general observation, regarding the preferred relationship types, it is noteworthy that `L` is pre-

	A		L		D	
1-1	**126**	**(38.89%)**	114	(35.19%)	84	(25.93%)
1-2	36	(8.85%)	96	(23.59%)	**275**	**(67.57%)**
1-3	32	(18.29%)	33	(18.86%)	**110**	**(62.86%)**
1-4	66	(18.23%)	70	(19.34%)	**226**	**(62.43%)**
1-5	4	(16.0%)	3	(12.0%)	**18**	**(72.0%)**
2-1	**248**	**(83.5%)**	16	(5.39%)	33	(11.11%)
2-2	70	(21.88%)	83	(25.94%)	**167**	**(52.19%)**
2-3	**116**	**(56.04%)**	28	(13.53%)	63	(30.43%)
2-4	**166**	**(43.01%)**	71	(18.39%)	149	(38.6%)
2-5	16	(37.21%)	8	(18.6%)	**19**	**(44.19%)**
3-1	**192**	**(83.84%)**	16	(6.99%)	21	(9.17%)
3-2	71	(27.52%)	50	(19.38%)	**137**	**(53.1%)**
3-3	89	(38.03%)	43	(18.38%)	**102**	**(43.59%)**
3-4	143	(35.93%)	90	(22.61%)	**165**	**(41.46%)**
3-5	**20**	**(48.78%)**	3	(7.32%)	18	(43.9%)
4-1	**342**	**(84.24%)**	29	(7.14%)	35	(8.62%)
4-2	146	(32.44%)	88	(19.56%)	**216**	**(48.0%)**
4-3	**167**	**(44.53%)**	45	(12.0%)	163	(43.47%)
4-4	**206**	**(44.21%)**	73	(15.67%)	187	(40.13%)
4-5	16	(43.24%)	3	(8.11%)	**18**	**(48.65%)**
5-1	13	(100.0%)				
5-2	3	(21.43%)	3	(21.43%)	8	(57.14%)
5-3	1	(14.29%)			6	(85.71%)
5-4	11	(55.0%)	3	(15.0%)	6	(30.0%)

Table 13. Results of the last-first pairwise relationship analysis.

ferred in only one case, namely 1-1 in the first-first relationship, and indeed in a significantly higher percentage than A and D. These results might indicate that in jingju singing the performance of two consecutive syl-

	A		L		D	
1-1	51	(15.74%)	**160**	**(49.38%)**	113	(34.88%)
1-2	10	(2.46%)	65	(15.97%)	**332**	**(81.57%)**
1-3	17	(9.71%)	23	(13.14%)	**135**	**(77.14%)**
1-4	33	(9.12%)	45	(12.43%)	**284**	**(78.45%)**
1-5	3	(12.0%)	1	(4.0%)	**21**	**(84.0%)**
2-1	**240**	**(80.81%)**	23	(7.74%)	34	(11.45%)
2-2	97	(30.31%)	79	(24.69%)	**144**	**(45.0%)**
2-3	**118**	**(57.0%)**	42	(20.29%)	47	(22.71%)
2-4	**179**	**(46.37%)**	59	(15.28%)	148	(38.34%)
2-5	**22**	**(51.16%)**	5	(11.63%)	16	(37.21%)
3-1	**183**	**(79.91%)**	21	(9.17%)	25	(10.92%)
3-2	74	(28.68%)	34	(13.18%)	**150**	**(58.14%)**
3-3	96	(41.03%)	39	(16.67%)	**99**	**(42.31%)**
3-4	131	(32.91%)	84	(21.11%)	**183**	**(45.98%)**
3-5	15	(36.59%)	4	(9.76%)	**22**	**(53.66%)**
4-1	**360**	**(88.67%)**	25	(6.16%)	21	(5.17%)
4-2	**211**	**(46.89%)**	104	(23.11%)	135	(30.0%)
4-3	**231**	**(61.6%)**	59	(15.73%)	85	(22.67%)
4-4	**254**	**(54.51%)**	82	(17.6%)	130	(27.9%)
4-5	**24**	**(64.86%)**	4	(10.81%)	9	(24.32%)
5-1	13	(100.0%)				
5-2	5	(35.71%)	3	(21.43%)	6	(42.86%)
5-3	2	(28.57%)			5	(71.43%)
5-4	12	(60.0%)	3	(15.0%)	5	(25.0%)

Table 14. Results of the first-first pairwise relationship analysis.

lables in a relationship that can be perceived as level is frequently avoided, or specialized in the expression of two consecutive tones 1.

As expected from the reviewed literature, tone 1 shows the most clear pattern. In all the pairs that contain this tone it is performed in a higher pitch than the other one. This tendency is more pronounced when tone 1 is the second syllable of the pair. The only special case is the pair of two consecutive tones 1. In this case, as already stated, the `L` relationship type is either the most preferred one, in the first-first relationship, or the second most preferred one, in the last-first relationship. In the second case, even being the second most frequent option, it is statistically very close to the most frequent one, `A`. This situation however presents a logical explanation considering that the most frequent syllabic contour of this tone is descending. Therefore, in a pair of tones 1, if both of them are sung with the same initial pitch, therefore presenting a level first-first relationship, and the first one is sung in the frequent descending syllabic contour, then the last-first relationship will be ascending.

The behavior of tone 2 in terms of pairwise relationship is also very consistent. In all cases but one, tone 2 is sung in a lower pitch than the preceding or following syllable. Besides pairs with tone 1, in which this trend is especially recurrent, with percentages over 80%, those pairs involving tone 3 also show a high preference for the low realisation of tone 2. The only exception is found when tone 2 is preceded by tone 4, in which case, the latter starts lower than the former, as shown in the results for the first-first relationship with `A` as the preferred relationship type. The results for the same pair in the last-first relationship though show `D` as the preferred relationship type. The apparent contradiction can however be explained by the common ascending syllabic contour of both tones 2 and 4, as shown in Table 12. When a tone 4 followed by a tone 2 presents an ascending syllabic contour, the results from Table 14 suggest that tone 2 starts in a higher pitch than the first note of tone 4, which at the same time is lower than the last note of the same tone 4's ascending syllabic contour. In fact, in the pairs involving both tones 2 and 4, the opposite relationship type in each case, which indicates a lower realisation of tone 4, also presents a higher percentage, showing that the relationship between both tones is quite flexible. Finally, when two tones 2 form a pair, usually the second one is sung lower than the first. Interestingly, these pairs also show a high occurrence of `L` relationship types.

Regarding the results for tone 3, a clear tendency of being sung higher than neighboring syllables is observed, with the only exception of pairs in which a tone 1 is involved, in which cases this one is generally sung higher than tone 3. This pattern is very similar to tone 1's behavior. However, the main difference with tone 3 is that the percentages are much smaller for the latter, in some cases showing the opposite relationship type also a quite high percentage. This points to a higher degree of variability in the sung realisation of tone 3 in relation with neighboring syllables. When a tone 3 follows another tone 3 is most frequently sung lower than the previous one, although the opposite relationship is also highly frequent.

Finally, the results for tone 4 show a tendency to be sung lower than neighboring syllables. The only apparent exception would be the most frequent `D` relationship type in the results for the 4-2 pair in the last-first relationship (Table 13). However, as previously explained, this fact might be explained by the mostly ascending syllabic contour of this tone. When two tones 4 are found in a pair, it is the first one which is usually sung lower than the second.

After the discussion here presented about the obtained results, two final interesting observations are worth making. Firstly, as in the case of the syllabic contours, the analysis of the pairwise relationship shows that tones 1 and 3 behave in a similar manner, being sung higher than neighboring syllables, even though tone 1 is much more consistent in this behavior, and tones 2 and 4 also share a similar performance, both being preferred to be sung lower than preceding or following syllables, although with frequent realisation of the opposite relationship type. Secondly, and also supporting a similar conclusion from the analysis of syllabic contours, the results for pairwise relationship suggest that the tonal contours of the HG dialect are the ones that would more consistently explain the relationships previously described.

6.4. Conclusions

The computationally extracted statistical information discussed in the present chapter aims at contributing with empirical data to the study of the relationship between tonal categories and melody in jingju singing. To that aim, the machine readable scores and the tone related annotations from the JMSC were used, and a code was written to automatically assign relationship labels and count their occurrence according to the three relationships that are commonly present in related literature, namely syllabic contour, last-first pairwise relationship and first-first pairwise relationship. The analysis of the obtained results regarding the relationships themselves show that, on the one hand, pairwise relationships seem to be generally established more in terms of the general pitch contour of the syllables of a pair than the relation between the first or last note of the first syllable and the first one of the second. However, between last-first and first-first pairwise relationships, it seems that the latter express more distinct trends. Taking these observations into account, the results suggest that both syllabic contour and pairwise relationship complement each other in the definition of the influence of tonal categories on melody.

From the analysis of the results, it is ostensible that tone 1 shows more defined and regular characteristics, with a predominantly descending syllabic contour and being sung in higher pitch than neighboring notes, except when two tones 1 form a pair, in which case they tend to be sung in the same pitch. Tone 3 shows similar characteristics, with a preference for descending syllabic contour and usually sung higher than neighboring syllables, but with much less consistency than tone 1. Tones 2 and 4 show similar behaviors, both preferring an ascending syllabic contour, especially frequent for the latter, and usually sang lower than neighboring tones. When tones 2 and 4 form a pair, usually tone 2 is sung lower. In any case, the results show that different options of both syllabic contour and pairwise relationship are commonly used, showing a high degree of variability in the melodic realization of tonal contours. Finally, the tendencies just described seem to be better explained taking as a linguistic reference the tonal contours of HG dialect.

These results however should be taken with caution, for two main reasons. Firstly, as pointed out in Section 6.1, the fact that grace notes were omitted for the analysis might have affected to a certain degree the final results, since the corresponding transcriber might have opted for using these ornaments to notate melodic inflections used for conveying tonal information. And this is precisely the second reason. The data used for this analysis, that is, the music scores, are discretised representations of the continuous melodic stream. As discussed in Section 4.2, several authors argue that the tonal information might be conveyed through nuanced melodic inflections, generally at the beginning of the syllabic contour (Wichmann 1991: 55, Zhang_4 2001: 47, Yu Huiyong 2008: 49–50). In those cases, it is not possible to infer from the music score the accuracy with which the transcribers notated these inflections, perhaps with grace notes, or just with some symbolic indication—in that case, ignored in the present analysis—, or if according to his or her transcribing goals the notation of such nuances were not relevant. Consequently, even though the results suggest some consistent and regular trends, a more in depth study is still required in order to obtain definite confirmation. And to this goal, perceptual studies about the reception of tonal information in jingju singers could provide with important guidelines for further research.

A final point regarding a common approach to the study of the relationship between linguistic tones and melody is worth making in the light of the results here discussed. In the study of this topic, some authors (Wichmann 1991, Zhang_5 1992, Stock 1999) refer to the concept of *ping-ze* tonal categories as a relevant aspect of this relationship. Arguably, the most influential study on this issue based on the *ping-ze* categories is Pian's analysis of the setting to music of one *dan xipi liushui* aria (1972). In this study, the author relates the use of certain recurring melodic motives to the tonal structure of line sections regarding the *ping-ze* categories. This classification groups tones 1 and 2 into the *ping* category and tones 3 and 4 into the *ze* category. However, the results here presented show similar patterns for tones 1 and 3 on the one hand, and for tones 2 and 4 on the other hand. It has to be pointed out that the *ping-ze* categories are an essential concept for the poetic structure of the lyrics lines. However, the just presented analysis would imply that such groups of tones 1 and 2 and tones 3 and 4 do not present an individual entity in the relationship between linguistic tones and melody. Notwithstanding this, it has to be pointed out that Pian's approach is different from the one presented here, since her analysis unit is the line section and the melodic pattern, whilst in my approach the analysis unit is the single syllabic contour, either individually or within a pair of syllables.

Chapter 7 Comparative analysis of jingju melodic lines

This chapter presents and discusses the results of the comparative analysis performed on the JMSC, supported and expanded with the statistical and quantitative information extracted with the use of the code written to that aim, and whose results are also presented and discussed here inasmuch as they contribute to the understanding of the analysed melodic lines. The first section of the chapter describes in detail the procedures for the implementation of the comparative analysis as well as the characteristics of the obtained melodic schemata. The second section is devoted to the description of the code developed for the extraction of statistical information from the analysed data, and the explanation about how it has been used and what information has been extracted. The remainder of the chapter consists in the presentation and discussion of the obtained results, grouped by different combinations of line categories. Finally, the chapter finishes with the final conclusions about the melodic identity of both *xipi* and *erhuang*, which are expected to be the main contributions of the present thesis.

7.1. Comparative analysis

The methodological framework designed for this thesis, discussed in detail in Chapter 3, has comparative analysis as its central method. Therefore, it requires a detailed explanation of how it has been implemented. In this section, I discuss first how the data were prepared in order to perform the analysis, then the analytical procedure is described, and finally, I ex-

		laosheng					*dan*				
		erhuang			*xipi*		*erhuang*			*xipi*	
		O1	O2	C	O	C	O1	O2	O	C	O
Manban 286, 31.81%	*manban*	12	21	33	9	8	23	13	36	25	25
	sanyan	2	4	6	9	8					
	zhongsanyan						2	1	3		
	kuaisanyan	4	9	13	3	3	1	6	7		
Yuanban 280, 31.15%	*yuanban*	33	23	56	23	24	12	15	27	28	27
	erliu									6	6
Kuaiban 333, 37.04%	*liushui*				42	38				60	61
	kuaiban				43	42				23	24

Table 15. Detailed information about lines in the JMSC.
The leftmost column shows total number of instances and its percentage from the overall collection for each *banshi* group.

plain the meaning and features of the melodic schemata resulting for such analysis, and that will be the basis for the discussion offered in the remainder of the chapter.

The data upon which the comparative analysis has been performed are the 899 melodic lines contained in the JMSC. In order to structure such high quantity of data, I devised certain criteria for grouping lines into musically coherent analysis units. As described in Chapter 4 there are four elements of the jingju musical system that are considered for the analysis here presented, namely role type, *shengqiang*, *banshi* and line type. For each of these elements, a specific set of instances have been considered to be included in the JMSC, namely 2 instances of role type, 2 instances of *shengqiang*, 8 instances of *banshi*, and 3 or 2 instances of line types depending respectively if the *shengqiang* is *erhuang* or *xipi* (Table 15). Each combination of instances from these four elements defines a specific line category, which is the basic analysis unit. Each line category is named, according with the Chinese use, with the combination of instances from each of the four elements, in the same order previously mentioned, that is, role type, *shengqiang*, *banshi* and line type—for instance *laosheng erhuang* *yuanban* opening line 1. To refer to wider categories, any element from the name can be omitted. In that case, the category refers to the combination of the specified instances given in the name, plus all the instances available in the JMSC of the omitted element and which results in existing line categories in the JMSC. For example, *laosheng xipi yuanban* refers to the combination of each of the given instances plus both opening and closing lines from the omitted line type element—it would not include opening line 1 and opening line 2 since these line types are not used in *xipi*.

To ease the practical implementation of the analysis, I take advantage from the fact that the scores are available in machine readable format and are thoroughly annotated to the line level, including the corresponding instances of the four elements of the jingju musical system per line, as well as the starting and ending offset of each line in the score. Benefiting from these annotations, I use the music21 toolkit in order to collect all the lines belonging to the same line category and group them together in a single stave system, so that all these related lines can be visualized in alignment using a music score editing software such as MuseScore. Since many lines present differences in terms of structure, specially with different number of measures per line section or between sections, a further process of manual alignment of the sections was implemented. As a result, I obtain a series of printable files, each of which contains all the lines corresponding to the same line category, vertically aligned to the line section level.[1]

Taking into account that for some combinations there are no lines in the JMSC, as shown in Table 15, the resulting number of line categories is 46. This quantity of line categories does not only poses some challenges for the implementation of the manual analytical process, but also in some cases results in too reduced groups of line samples, like *dan erhuang zhongsanyan*. Consequently, with the aim of simplifying the number of analytical units, and at the same time obtain a better balanced quantity of samples per category, considering that the goal of the analysis is to contribute to the understanding of *shengqiang*, I decided to group the *banshi*

[1] The code for retrieving and grouping the melodic line is fairly straightforward and simple. Besides, the manual work for alignment the line sections was quite intensive, so that the final files importantly differ from those automatically generated. Consequently, I argue that the used code is not relevant enough to be shared. However, even though the files with the aligned melodic lines can not be publicly shared due to copyright issues, they are available for research purposes, as described in the thesis' companion web page.

instances into three groups according to their metre. Metre is not only one of the most relevant aspects in the system of metric changes, and in fact the one that gives name to the whole system, but also an objective, easily identifiable characteristic, well established in music notations. Therefore, it seems as both musically meaningful and a pragmatically straightforward feature to take as a grouping criterion. The first group is formed by *yuanban* and *erliu*, both of them sharing the same 2/4 metre. The only exception is *dan xipi*, whose *yuanban* is conventionally performed with a 4/4 metre. However, in order to maintain musical coherence, it is also included in the group. The second group is formed by the 4/4 *banshi*, namely *manban*, *sanyan*, *zhongsanyan* and *kuaisanyan*. All these *banshi* are understood as a slowing down of *yuanban*, and in fact that is the literal meaning of *manban*, 'slow *banshi*'. On the other hand, as already explained (Section 4.5), *sanyan* is commonly understood as an alternative name for *manban*. Finally, the last group consists of *liushui* and *kuaiban*, both in 1/4 metre, since they are understood as a speeding up of *yuanban*, and *kuaiban* indeed literally means 'fast *banshi*.' In order to easily refer to these *banshi* groups, I will henceforth refer to them by the first *banshi* in the group as previously listed, which is also the most representative *banshi* in the group, but in regular script and the initial letter in uppercase. Therefore, the first group will be referred to as Yuanban, the second as Manban and the third as Kuaiban. As shown in Table 15, each of these three *banshi* groups stand for approximately a third of the total lines in the JMSC. As a consequence of this grouping, the number of lines categories, that is, of analysis units, is reduced to 24. For the naming of these line categories, instead of using the specific instance of *banshi*, the name of the *banshi* group is used instead—as in, for example, *dan xipi* Manban closing line.

Once the line categories are defined and their corresponding samples in the JMSC grouped and aligned in individual files, the data are ready to be analysed. The comparative analysis is performed on each line section, which are clearly marked in the files of aligned lines. In certain occasions though, the result of the analysis might show that a particular boundary between sections, which as explained in Section 4.2 are taken from the lyrics structure, might not be consistent with melodic performance. The goal of the comparative analysis is to identify the underlying melodic motion that is shared by all, or by most of, the analysed samples. The focus is put on those pitches that propels the melody towards specific intermediate or final goals. In this sense, the predominance of a pitch is not defined by its more frequent use, in which case it could be easily inferred by quantitative methods, but by its influence in the directionality of the melody. In most cases, this predominance coincides with a higher frequency of use in the analysed unit—in most cases, the line section—and in fact, this is an important factor in the analysis, but there is not a necessary relationship between use frequency and predominance for melodic motion. Consequently, the factors considered for establishing this predominance are the following ones:

- occurrence frequency in the considered analysis unit,
- duration of the notes for each pitch,
- metrical position (accented or unacctented beat),
- starting note of a syllable,
- cadential note of a section or subsection,
- recurring turning point in melodic motion, that is, if melodic direction frequently changes upon a particular pitch.

From this analysis, a melodic schema is built that represents the underlying melodic motion of a given line category. Since the goal is to identify this underlying melodic motion that is shared by all or most of the analysed samples, the specific rhythmic configurations are not considered for the construction of the resulting melodic schemata. Even though *shengqiang*, which is the goal of this analysis, do have some metrical implications, as presented in Section 4.4, the rhythmic features, which as discussed in Section 4.1 are fundamental for jingju expressivity, are, in structural terms, related to the concept of *banshi*, or in performative terms, related to the specifics of the sung passage. The metrical and rhythmic structure of *banshi* has been thoroughly analysed in the state of the art literature (Schönfelder 1972, Liu_1 1992, Zhang_5 1992, Jiang_2 1995). The absence of rhythmic information in the obtained melodic schemata—with few exceptions that will be pointed out below—should not therefore be understood as unimportance of this aspect, but as a not essential element in the understanding of *shengqiang*'s melodic identity. The presentation of the resulting melodic schemata as aiming to capture underlying melodic *motion* aims at stressing the importance of the temporal dimension in jingju singing.

Regarding the representation of the aforementioned melodic motion, I consider two hierarchical levels, represented in the melodic schemata as follows. Open noteheads indicate structural pitches, that is, pitches of greatest predominance across analysed lines, and which determine the milestones of melodic motion, either as origin point, destination point or turning points, and occasionally necessary continuation points. The isolation of these pitches from the melodic schema indicates the innermost level of melodic construction. Filled-in noteheads indicate directional pitches, that is, the most frequent pitches to fill the melodic motion towards, from or between structural notes. If a particular direction pitch is frequently present across samples, but not with great consistency, it is represented in the schema with a small size filled-in notehead. The melodic line drawn in these schemata do not establish a necessary fixed structure which is simply embellished in performance. Besides the addition of passing or ornamenting notes, certain melodic phrases from the schemata can be repeated, broken before reaching its melodic goal and started again, occasionally omitted or substituted by a neighboring pitch. Slurs are used in the schemata with two purposes. The first purpose is to indicate a direct melodic motion between the pitches included in the slur, so that interpolated pitches are very rare and therefore constitute a characteristic melodic pattern. On the other hand, two notes of the same pitch joined by a slur indicate a melodic region in which this pitch predominates, also across line sections. In many occasions more than one melodic motion is observed in the same line region. In these cases, whenever possible, the different possibilities are notated in the same staff and aligned vertically. When the complexity of the two possibilities prevents from notating them in the same staff without hindering its understandability, the less frequent melodic motion is notated in an extra staff excerpt, vertically aligned with its corresponding alternative. Finally, in the very rare occasions when a melodic pattern, including its rhythmic shape, is specially recurrent, its rhythmic component is also notated in the melodic schema (see Figures 7 and 13).

It has to be noted that the number of notes in the schemata do not necessary reflect the complexity of the melodic surface. Since the goal of these representations is to extract the most frequently occurring pitches, it might be the case that in certain line categories with a high degree of melodic complexity and at the same time a high level of variability across lines, the schema only present few of the pitches actually performed. A high number of notes in the schema is a sign of a greater stability in melodic surface. The schemata reflect the line sections structure through barlines. The common caesura in the third line section is indicated with a tick. In many cases, *tuoqiang* or melismatic extensions are commonly used at the end of a section. To analyse these phenomena, I added them after a double barline. In some cases, I have observed a structural influence of tonal categories, specifically of tone 1, in the melodic motion. As described in detail in Chapter 6, tone 1 characters are generally sung in a higher pitch than neighboring characters. By structural influence I mean that a particular pitch or even melodic phrase in that particular line type is specialized in the singing of tone 1. In those cases, I add in the melodic schema the cipher 1 below or above—just according to its better readability—the pitch used to sing tone 1. If it appears between brackets, it indicates that the specialization of that pitch for singing tone 1 is not exhaustive, so that either tone 1 in that position can be sung occasionally in other pitches, or that the marked pitch can be used for singing other tones—usually tone 3 or tone 2. Finally, if a particular melodic schema shows a special feature, it will be described along with its analysis in the following sections.

7.2. Statistical and quantitative data

In order to automatically extract statistical and quantitative information from the JMSC, a code was written using the previously mention music21 toolkit as main resource. According with the CompMusic project's commitment with open research, the code is openly available. Therefore, with the aim that the research community can benefit from it for future similar research tasks, in this section I describe first which are the functionalities of the code, and how it can be used. Then, I present how it was used for the present thesis, and which are the obtained results. These results contribute to the comparative analysis described in the previous section and are used to support and expand the analysis discussion in the next section of the chapter.

Description of the code[2]

The code for the analysis of the singing lines of the JMSC is written in Python, so I will use this programming language terminology in order to describe it. This code is designed to exploit the JMSC, therefore it requires its collection of machine readable scores in MusicXML format, as well as the `lines_data.csv` file that contains all the related annotations.[3] The script contains five main functions, plus a series of auxiliary ones designed to manage the data, performed secondary tasks and control the plotting characteristics. In this case, the code is written in such as way that all the auxiliary functions are called from the main ones, so the following description will focus only on these.

All these five main functions share a common set of parameters. The only positional parameter required by each function is the path of the `lines_data.csv` file, since the contained annotations are fundamental for retrieving the needed lines to be analysed. The code is written assuming that this file is stored in the same folder as the MusicXML scores collection. Then, four default parameters are available to specify the instances of the four jingju musical system elements that define the line or broader category to be analysed. These parameters work with the same logic as the naming criteria previously mentioned, so that if no value is input for a given parameter, all the existing instances for the corresponding element are considered. Consequently, if no value is passed to any of these four parameters, the whole JMSC is analysed.[4]

When each of these functions is run, the validity of the input values is checked, and if any no valid value is input, the user will be required to either enter a valid one, skip it or stop running the code. If the computa-

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[2] A preliminary version of this code was presented in Caro et al. (2017a).

[3] As stated in Section 5.2, it is expected that the JMSC might grow in the future with the addition of new scores. As long as these scores are created with the same criteria as the one contained in the JMSC and annotated in the same manner (Section 5.2), the code here presented can still be used for future versions of the JMSC.

[4] These four parameters are called with a two letter abbreviation of the corresponding element according to its Chinese original name, so that role type corresponds to the parameter `hd`, *shengqiang* to the parameter `sq`, *banshi* to the paramenter `bs`, and line type to the parameter `ju`. The values should be input in the form of a list, written in their full name as they appear in Table 15, except for line types, in which case the required values are `s` for opening line, `s1` and `s2` for opening lines 1 and 2, and `x` for closing line.

tion is successfully implemented, a message will be printed in the console indicating the number of lines that matched the given combination of instances. If for any of the input instance no line was found in combination with those for the reminding elements a warning message is printed to the console with the specific details. Each function returns either a list or a dictionary with the numeric values of the features measured. If a file name is passed to the parameter `filename`—set by default to `None`—a plot will be generated and saved with the given file name. Besides the aforementioned ones, each function contains a series of parameters of their own, to control specific aspects. I will describe now the motivation and goal of each function, its specific parameters and the returned output.

- **`pitchHistogram`**. This function measures the relative aggregated duration of each of the pitch values present in the input combination of instances.[5] The measuring unit is the crotchet, according with the `quarterLength` attribute used by music21 to set a note's duration. The purpose of this function is threefold. The first goal is to the define the set of pitch values sung, that is, the pitch space of the anlaysed category, which provides information about the scale used, and especially about the use of the so-called 'coloration tones,' that is, the 4th and 7th degrees. Second, such histograms determine the register and the range of the pitch space, specially in relationship with the first degree of the scale. This sheds light on the pitch region that receives major focus. And thirdly, this information allows to observe which pitches are more prominently sung by the actor or actress—and therefore which pitches the listener is longer time exposed to—and infer from that predominance their relative importance.

  Besides the parameters previously described, this function contains two further default parameters. The first one, `count`, sets the normalization method for the results. It takes three possible values. The default `sum` normalizes the result to the summation of the duration of all the pitch values present. `max` normalizes the result to the highest computed value, while `abs` returns absolute

[5] Music21 provides an inbuilt class named `graph.PlotHistogramPitchSpace` which also computes a histogram of the pitch values present in a given input. However, this class counts the number of notes independently of their duration.

values without normalization. The second one is `countGraceNotes`. When it is set to `True`, which is its default value, the grace notes in the score will be also computed. Since music21 assigns no duration to grace notes—their `quarterLength` value is 0—a standard duration is assigned by the function, equal to the smallest duration value present in the analysed melody, but never higher than 0.25 (a semiquaver). If this parameter is set to `False`, grace notes will be ignored.

The function returns a list with all the found pitches, which are in turn returned as two items list, namely the pitch name with its octave, and the normalized—or not—aggregated duration value. The general list is ordered from the lowest to the highest pitch value. On the other hand, if a file name is passed to the `filename` parameter, a histogram with these results will be plotted and stored as a `png` image file with the given name.

- **`pitchHistogramLineJudou`**. This function is in all equivalent to the previous one, including purpose, default parameters and output results. The main difference is that the computation is done separately for each of the three sections of the line. The goal is to observe how the melodic line progresses in terms of preferred pitch regions or pitch values. The function returns, instead of one as in the previous function, three lists, one per line section, the three of them included in a single list. Each of the sections contain the total pitch classes found in the overall analysis, and if in any of the sections a particular pitch value is not present, the symbol `--` is output instead of a duration value. The returned plot provides the three histograms, displayed vertically, sharing the same general pitch range and aligned in terms of pitch values, for a better comparison.
- **`intervalHistogram`**. Similarly to the previous functions, this one measures the relative aggregated occurrence of each of the interval classes present in the given combination of instances, by simply counting them. As explained in Section 4.4, one of the agreed differences between *erhuang* and *xipi* is the major use of

larger intervals of the latter compared with the former. This function aims at observing and measuring this claim.

The `intervalHistogram` function includes the `count` and `ignoreGraceNotes` default parameters, with the same function and default values as in the `pitchHistogram` function. Besides these, it also contains two more default parameters. If `directedInterval` is set to `False`, which is its default value, the retrieved interval classes do not specify the direction of the interval, that is, ascending or descending. If the passed value is `True`, ascending and descending intervals of the same quality and number are counted separately. Finally, the `silence2ignore` parameter establishes the duration threshold for a rest to be ignored in order to count the interval formed by the previous and following notes. The goal of this parameter is to avoid that the interval formed by a pair of notes separated by a small rest, which might be effectively perceived as a melodic interval, will be ignored. The default value is 0.25, which implies that pairs of notes separated by rests with a duration longer than a semiquaver will be ignored to form an interval.

The results are returned by this function in a similar manner as in the `pitchHistogram` function. The interval value consists of the initial of the interval quality, followed by its number. If the direction of the interval is considered, descending intervals are marked with a minus sign between the quality initial and the number. The intervals are ordered from lower to higher melodic difference, measured in semitones according to the music21 method. If a file name is passed to the `filename` parameter, a histogram with these results will be plotted and saved.

All the histograms plotted by the three previous functions share a visual code to ease interpretation. If the plots present results only regarding the *laosheng* role type, the bars color is blue, if they present results only regarding the *dan* role type, the bars color is orange, and if they present results regarding both of them, the bars color is gray. On the other hand, if they present results regarding only *erhuang*, the bars hatch has a `/` pattern, but they have a `\` pattern if they present results only regarding *xipi*. If the results concern the two *shengqiang*, a `X` pattern is used as hatch.

- **`cadentialNotes`**. As stated in Section 4.4, a common element to set apart *xipi* and *erhuang* is the set of preferred cadential notes. With the aim of studying which are the actual pitch values used as cadential notes in the JMSC, this function simply counts which pitch values appear as the last note for each section of the opening and closing lines of the given combination of role type, *shengqiang* and *banshi*, and compute their percentage of occurrence. Therefore, this is the only function that does not need a parameter for the line type, since it computes results for the three sections of all the applying line types. That is, for *xipi*, opening and closing line types are computed, and for *erhuang*, opening line 1, opening line 2 and closing lines are considered. Consequently, this function do not allow combinations of the two *shengqiang* instances. On the other hand, since different sets of cadential notes are defined for *laosheng* and *dan*, this function do not allow combinations of these two role types either. If any of such combinations is input, an error message is printed on the console asking the user to solve the issues.

  Besides the common default parameters, this function also includes the `includeGraceNotes`, with the same function as in the histograms, and with `True` as default value.

  The results returned by the `cadentialNotes` function are similar in format to the histogram functions in that for each section of each line type a list with the total set of retrieved pitch classes is provided, together with their percentage of occurrence as cadential note. Those pitch values from the retrieved total that do not occur as cadential note in a particular section of a particular line type are given the value of 0.0. The lists are organized in dictionaries. There is one for each line type, in which the results for each section can be accessed with the keys `S1`, `S2` and `S3`. Then, the line types are in turn also included in a dictionary, and they can be accessed through the keys, `”Op. line”` and `”Cl. line”` in the case of *xipi*, and `“Op. l. 1”`, `”Op. l. 2”`, and `”Cl. l.”` in the case of *erhuang*. The returned plot, in case a file name is input, provides a chart of stacked bars per line section. A legend of colors is provided, in which each color is associated with a pitch value, and the octave is specified via the hatch pattern, so that `x` indicates the lower octave, circles indicate the higher octave, and the central octave is kept without hatch.

- **`melodicDensity`**. Elizabeth Wichmann, as pointed out in section 4.5, refers to the number of pitches per syllable or per line in order to differentiate *banshi*. Drawing on this observation, this function measures the average melodic density per syllable, with the goal of observing differences in this regard across *banshi* and *shengqiang*. The function computes results individually for each of the scores in which lines that match the input combination of instances are found, as well as average results aggregating all the lines retrieved across scores.

  As specific default parameters, this function takes `includeGraceNotes` and `notesOrDuration`. The former is the same as in the previous functions and its default value is `True`. The latter specifies the unit for measuring the melodic density. If `notes`, its default value, is passed to this parameter, the melodic density is measured in terms of number of notes per syllable. If `duration` is passed, it is then measured in terms of aggregated notes durations, taking the crotchet as unit, as in the case of the pitch histograms.

  As previously mentioned, the `melodicDensity` function computes results per score and for the average of all the retrieved lines. Therefore these results are returned in a dictionary per score plus one for the average results. These dictionaries are in turn included in a global dictionary, from which the score results can be accessed using the number given to each one in the plot as key, as well as the key `Avg` to access the average results. Each of the score dictionaries contain the following keys and information: `score`, whose value is the corresponding score's name, `median`, `Q1` and `Q3` for the corresponding quartiles, `lower fence` and `upper fence`, and `outliers`. If a figure is returned by passing a file name, the results are visualized through a box plot per score plus one for the average results.

Finally, each of these functions also contain a series of default parameters for setting the size of different elements of the plots.

For the sake of granting the reproducibility of the results and plots used in this thesis, I wrote a piece of code named `JMSC_plots.py` with which all of them can be computed with a single command line. This code returns all the plots for every function, for all the combination of input items and with the specific set of parameters employed to generate the data and figures used for this thesis. In order to run this plot, the only required parameter is the path to the lines-data.csv file, which should be stored in the same folder as the XML scores. The user can also specify one or several of the seven set of plots considered in the thesis (Annex 2). The code generates a folder name `plots`, within which a new folder is created for each of the set of plots computed, and where the returned figures are stored. This code also produces a single `csv` file per set containing the numerical results corresponding to the plots, which is also stored in the same folder as the related plots. The documentation of the code provides a more detailed description of its functionalities.

Resulting data and plots

Each of the five main functions previously described allow a great number of possible combinations, not only considering the instances of the four jingju musical system elements, but also the different options that are specific to each of them. The aim of this design is to let them be as customizable as possible for future research. However, regarding the research task addressed in this thesis, a rationale was established in order to limit the possible options and to obtain the data and plots that might contribute to the research here undertaken. As a result, seven sets of plots, with their corresponding numerical data, were produced and used to support and expand the comparative analysis performed on the selected 24 line categories. All the obtained plots and numerical data are attached to this thesis as figures and corresponding tables in Annex 2. In order to indicate that a figure or table from this Annex is referenced in the text, their numbering is preceded by the letter ‘a’ plus the number of the set to which it belongs, followed by the specific number of the plot or table. I describe here then the criteria followed for using the code to obtain these seven sets, listed with the just described numbering code.

a1. Pitch histograms per line. This first set is computed using the **`pitchHistogram`** function. As previously stated, the results of this function can be used to analyse the pitch space, register and range, and the relative distribution of pitch occurrence. This information might shed information for the characterization of different levels of analytical categories, from the broadest to the most specific. In order to benefit from this potential, I applied the function to this range of analytical categories. In the broadest level, I compute pitch histograms for *laosheng*, *dan*, *erhuang* and *xipi* individually. This means that for each case, all the instances of the remaining elements were included. Then, the function was applied to the combinations of the two role types with the two *shengqiang*. The next level considers each of the categories from the previous step combined with each *banshi* group—excluding any combination of *erhuang* and Kuaiban. Finally, the most specific level is the line category, according to which all the possible combinations for the four elements are considered. As a result, this set contains 42 plots and their corresponding numerical data. As for the `count` and `countGraceNotes` parameters, they were left to their default values, namely `sum` and `True`. This implies that the results are normalized to the summation of the values of all the retrieved pitches, and that grace notes are also considered, therefore offering the most detailed scope of the analysed categories.

a2. Pitch histograms per line sections. The analysis of the pitch space on which each line section focus might also contribute to the characterization of the analysed elements from their broadest to their finest level of analytical category. Therefore, the **`pitchHistogramLineJudou`** function is applied to the same combinations considered for the previous set, thus returning also 42 plots and their corresponding numerical data. In order to obtain the most detailed analysis of the pitch space per line section, the `countGraceNotes` parameter was also left to its `True` default value. Finally, since the information obtained from these plots and those from the previous set is closely related, the `count` parameter is also left to the default `sum` value, so that these and the previous histograms can be compared.

a3. Non directed interval histograms. State of the art literature refers to intervals mostly as an identifying characteristic of *erhuang* and *xipi*. Therefore, the **`intervalHistogram`** function is applied to both these analytical categories, that is, each of them combined with all the instances of the remaining elements, in order to study such claims. However, since this functions allows the analysis of other categories, both *shengqiang* instances were combined with each instance of role type, in order to study if this element has an influence in their intervallic space. Further on, each combination of role type, *shengqiang* and *banshi* group was also analysed, with the aim of observing the influence of *banshi* in the use of intervals. Finally, plots and data for each role type individually were also computed, in order to analyse if their singing can be characterized by a specific use of intervals. As a result, 18 plots with their related numerical data are returned. In this set, the `directedInterval` parameter is maintained in its default value `False`, so that the retrieved intervals do not take ascending or descending direction into account. Finally, the `silence2ignore` parameter is left also to its default value, a semiquaver, so that all the obtained results show an overall homogeneity.

a4. Directed interval histograms. This set of plots is obtained by applying the same function to the same analytical categories as the previous set. Therefore, it also contains 18 plots and related data. The main difference is that the `directedInterval` parameter is set to `True`, so that the ascending or descending direction of the retrieved intervals is considered. The aim is to study if any preference for the use of specific intervals in their ascending or descending forms can be identify as a defining trait of any of the analytical categories.

- **a5. Cadential notes**. To obtain empirically produced schemata of cadential notes, directly extracted from a collection of data, is the aim of this set. Since the **`cadentialNotes`** function, written to this aim, on the one hand, do not allow for analytical categories that combine the two instances of role type or the two instances of *shengqiang*, and on the other hand, it computes results for all corresponding line types, the analysed categories were the 14 combinations of role type, *shengqiang* and *banshi* group instances, returning the same number of plots and related data. In some score editions, occasionally a line or line section ends with a grace note. Therefore, the `includeGraceNotes` parameter was kept to its `True` default value.

- **a6. Melodic density as notes**. Melodic density is used by Wichmann to characterize *banshi*. In order to analyse this factor from the data in the JMSC, the **`melodicDensity`** function was used for each *banshi* group category, that is, each combination of role type, *shengqiang* and *banshi* group. From preliminary results, the returned box plots showed great potential for the study of the length of the melismatic expansion that usually occur at the end of some line sections called *tuoqiang*. The outliers in these plots, since reflect syllables sung with an unusual long string of notes, can be identified as a *tuoqiang*. Therefore, in order to study this phenomenon in different line types, and at the same time observe if there is any changes in melodic density among different line types, the function was also applied to each combination of the four elements. As a result, 34 plots and their corresponding data are obtained. In this set, the parameters `includeGraceNotes` and `notesOrDuration` keep their default values, respectively `True` and `notes`. Wichmann conceives melodic density as the number of notes sung per syllable. In this set this definition of melodic density is maintained, for which reason grace notes are also counted.

- **a7. Melodic density as duration**. The `notesOrDuration` parameter of the **`melodicDensity`** function can also take `duration` as a value. In this case, melodic density is conceived as a the total duration, measured in quarter notes, used for singing a syllable. This conception of melodic duration allows the study of the influence of tempo and metre changes among *banshi* on the metrical position of sung syllables, as well as detecting sustained prolongations of certain pitches in specially expressive passages. Therefore, this set contains also 34 plots and related data, obtained from applying the same function to the same analytical categories as the previous set.

In the following section, many data are extracted from these sets of figures and tables to support and expand the discussion on the melodic schemata obtained from the comparative analysis. Even though not all single plots are used in this thesis, these data might bear some information to other researchers who might look at them from a different perspective or with different aims. Therefore, I considered the collection of resulting plots and data as an important contribution of the research work presented in thesis, worth publishing in its entirety.

7.3. Discussion of the results

This section presents the most important contribution of the thesis, namely the melodic schemata resulting from the comparative analysis of the 24 line categories. The discussion here presented is based in the state of the art knowledge of the jingju music system (Chapter 4) and the experience obtained during fieldwork in NACTA (Section 3.2). The observations about the presented melodic schemata are supported and specified by the computationally extracted data. These plots and data also offer new insights not directly observable in the melodic schemata, therefore expanding the information obtained from them. As stated previously, figures and tables from the Annex 2 referenced in the text are identified in their numbering by the preceding letter ‘a.’ For the discussion of the melodic schemata, I will refer to particular notes using its equivalent in *jianpu* notation—that is, referring to its value as degree of the scale rather than as a specific pitch.[6] In this way the description is independent of key, and

[6] See footnote 7 in Chapter 4.

therefore generalizable for notations in other keys. Since the key established for the melodic schemata here presented is E, in the following discussion 1 is assigned to E4.

The structure of the section follows the goal of the undertaken task and the common assumptions about the jingju musical system, as summarized in Section 4.6. Since the goal is to understand *xipi* and *erhuang*, each subsection compare lines of the same categories from both *shengqiang*. According to the assumption that the *laosheng yuanban* is in each *shengqiang* the origin of the remaining *banshi*, the discussion starts with this combination of role type and corresponding *banshi* group. Then, the analogue lines for the female singing are discussed. Once all the lines for Yuanban have been presented, the Manban *banshi* group is discussed, first for *laosheng* and then for *dan*. Finally, since Kuaiban is only performed in *xipi*, the last subsection discusses the male and female singing lines for this *shengqiang* and *banshi* group combination. In order to simplify and ease readability, each line type will be referred to with an abbreviation, namely O for Opening line, O1 for Opening line 1, O2 for Opening line 2 —the last two respectively corresponding to the long version and the short, similar to closing line version of opening line in *erhuang* (Section 4.4)—, and C for Closing line. Equally, each line section is referred to as respectively S1, S2 and S3. Since S3 is usually divided into two subsections, they will usually mentioned as S3.1 and S3.2. When line type and any of its sections are mentioned together, their abbreviations are linked by hyphen—for instance, O1-S2.

***Laosheng erhuang* and *xipi* Yuanban**

Figure 7 shows the melodic schema for *laosheng erhuang yuanban* O1. As explained previously, the metrical structure of the line is not reflected in the schema, as it is well discussed in the state of the art literature. How-

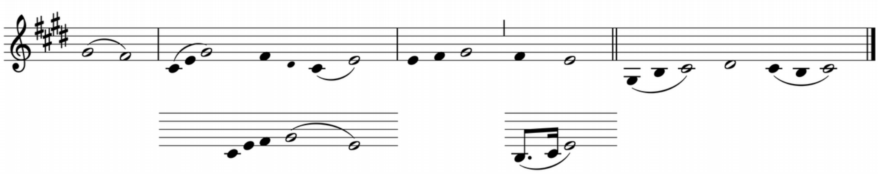

Figure 7. *Laosheng erhuang* Yuanban opening line 1.

ever, it should be pointed out here that a long instrumental interlude is commonly assumed to be performed between S2 and S3. Consequently, considered in this way, the melodic motion traced by the structural pitches (open note-heads) presents the following design, **3231**, **31**, with a structural caesura between S2 and S3. The **31** motion of S2 is maintained in the alternative melodic line (extra stave), with the difference that in this case the **31** motion is direct, without intermediate notes and with a longer preparation. The common assumption in the state of the art literature is that this line cadences on **1** (Section 4.4), which is the case of this line's S3, but also of S2. Considering that an instrumental interlude follows, which introduces S3 with the same melodic motive as for S1, all these factors confer S2 a conclusive character, so that S1 and S2 can be in fact perceived as a melodic unity with two sections. S1 has **3** as first structural pitch, and rests on **2**, producing a status of suspended conclusion. S2 retakes **3** as first structural pitch, indicating the start of a new melodic entity, which in this case presents a clear concluding mark with **1**. Figure a5.5 shows how consistent are these two pitches, **2** and **1**, as cadential notes of respectively S1 and S2. After the instrumental interlude, S3 presents a structure closer to S2, restating the concluding character. In fact, S3 usually ends with the pattern **5·61**, shown in the extra stave. This ascending movement of three consecutive scale degrees, specially in this rhythmic pattern, possess a common conclusive function, as it will be shown throughout the discussion. A structural difference with S2 is that S3 generally maintains a metrical caesura before the last two characters. The general structure of the line supports Zhang$_3$ Yunqing's description of the melodic structure of *erhuang* couplets as consisting in "two and a half [melodic] lines" (2011: 344–349). According to her understanding, S3 is understood as half a melodic line, and the analysis here presented provides evidence that it can be effectively perceived as the second, conclusive part of a melodic line formed by S1 and S2.

An interesting factor that can be observed in Figure a2.10 is how the pitch range of S1 is almost restricted to **1**, **2** and **3**, and how S2 and S3 considerably expand the range to lower pitch regions. In general, Figure a1.10 shows that the predominant pitch range of this line lies from 6̣ to 3, with a very reduced use of 7̣.

Many of these lines (14 out of a total of 33) conclude with a *tuoqiang* or melismatic extension. It is introduced by the characteristic ascending pattern of three consecutive scale degrees, in this case resting on 6̣, which is also the cadencing note, as commonly stated in literature (Table 4). The *tuoqiang* progresses with an agile melodic motion which has 7̣ as pitch centre, in occasions including the same ascending pattern of three degrees resting on 6̣. Figure a5.5 shows that 6̣ is more commonly used as cadential note than 1, specifically a 51.52% of the total cadential notes (Table a5.5), indicating the frequent use of *tuoqiang* in this line. A characteristic motive 6̣5̣6̣ marks the conclusion of the *tuoqiang*. The complexity of these *tuoqiang* can be seen in Figure a6.2, where the outliers of the box plots can be understood as *tuoqiang*, most of them consisting in 10 to 17 notes, but some of them reaching to 31, 32, and even 45 notes (Table a6.2).

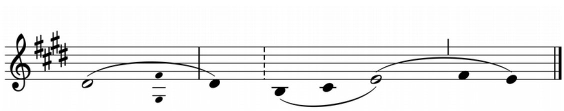

Figure 8. *Laosheng erhuang* Yuanban opening line 2.

If the combination of the just described O1 with C—to be described below—forms the asymmetrical structure characteristic of *erhuang* (Section 4.4), O2 in combination with C forms a symmetrical structure. Figure 8 shows how, compared with O1, the pitch range here focuses mostly on the region below the first degree. Comparing Figures a1.10 and a1.11, two remarkable observations can be done. Firstly, the pitch range is shifted downwards, losing the predominance of 3, which is gained by 5̣. Secondly, the barely used 7̣ in opening line 1 shows in opening line 2 a clear importance.

The boundaries between sections in O2 are mostly lost within a continuous melodic stream. A good indicator of this circumstance is Figure a5.5, which shows a great variety of cadential notes for S1 and S2 without a clear predominance of any of them, suggesting that these positions are not felt as resting points. S1 and S2 are usually separated by a short rest, which never occurs between S2 and S3. The caesura between S3.1 and S3.2 is however consistently maintained, and generally the only rest perceived. As a result of this circumstance, the metrical position of the pitches indicated in Figure 8 should be taken with flexibility. The first structural pitch, 7̣, is generally established in S1, as it can be observed in Figure a2.11, and it can be prolonged to S2, with an occasional cadence in either 2 or 3̣ in case there is a short rest. The mentioned Figure also shows how the structural degree 1, which is predominant in S3, is practically avoided in S1. This degree 1 can already be reached in S2 or be delayed to S3.2.

From the 23 lines belonging to this category, only 2 cases (samples 1 and 5 in Figure a6.3) present a very short *tuoqiang* or melismatic extension, which shows the same melodic motion of *tuoqiang* in O1 (Figure 7), with a sustained presence of 7̣, and cadencing in 6̣. However, Figure a5.5 shows an unexpected high presence of this degree as the cadential note of S3. An inspection of the scores shows that most lines present the cadential cell 16̣, which can be understood as a notation convention of the transcribers to indicate a descending inflection after the cadential 1, which is the note resting on strong beat.

Figure 9. *Lasosheng erhuang* Yuanban closing line.

The melodic structure of *laosheng erhuang yuanban* C (Figure 9) is very similar to O2. As already mentioned in Section 4.4, the structure of O2 is considered by Zhang5 as a variation (变化形式 *bianhua xingshi*) of O1 that takes the form of C, and therefore this structure that is shared by O2 and C is called by this author ‘form of connected lines’ (1992: 42). As in the case of O2, the variety of cadential notes showed in Figure a5.5 for S1 and S2 indicate the lack of a clear resting point in these positions. If this is the case in terms of metrical structure, in terms of melodic motion

O2 and C show clear differences. Firstly, the cadential notes are, as expected, different. O1 and O2 have to maintain the melodic function of opening line, therefore cadencing on **1** (or **6̣** in the cases of *tuoqiang*). The closing line has a conclusive function regarding the whole couplet, and therefore cadences on **2**, or in **5̣** if a *tuoqiang* is performed. Indeed, Figure a5.5 shows how **2** is the most preferred cadential note, accounting for 69.64% of the cases according to Table a5.5, followed by **5̣**, used in 23.21% of lines.

Secondly, C presents a more complex melodic motion than O2. Figure a1.12, when compared with Figure a1.11, shows richer use of the pitch range, and a change in the relative predominance of the different degrees, so that in C **2** gains importance over **7̣** and **1**, which were relevant degrees in O2. From the two alternative melodic variants shown in Figure 9, it can be inferred that the **6̣32** motion is the most characteristic one, and therefore the pitch range is wider than in O2, where it is mostly kept in the lower region below **1**. This **6̣32** motion can start as soon as in S1, or it can be postponed to S3—or S2, considering the blurred section boundaries. In the latter cases the degree **7̣**, generally approached from **2**, precedes the mentioned motion, showing in this case a closer proximity to O2 in terms of melodic outline.

Finally, C usually is finished with a *tuoqiang*, as can be seen in Figure a6.4. This Figure also shows that they are quite contained in terms of length, usually between 8 to 18 notes (Table a6.4). Although the *tuoqiang* is again sustained around **7̣**, as in the case of O1, the cadencing degree is **5̣**, as already mentioned. It is interesting to note that the 'coloration tone' **4̣** is usually sung in the motion towards the final **5̣**, and that different transcribers will notate it as **4̣** or **#4̣**.

The metrical structure of *laosheng erhuang yuanban* melodic lines shows a clear contrast with the structure of lyrics lines. O1, using the aforementioned Zhang$_3$ Yunqing's understanding, sets the opening line of the couplet of lyrics to one and a half melodic lines, whilst in O2 and C, the end of lyrics' S1 is briefly marked with a short rest, the boundary between lyrics' S2 and S3 is blurred, and the caesura between S3.1 and S3.2 consistently marked. Therefore, the characteristic asymmetry of *er-*

huang melodic lines is not only expressed between themselves, but also between them and the structure of the lyrics lines.

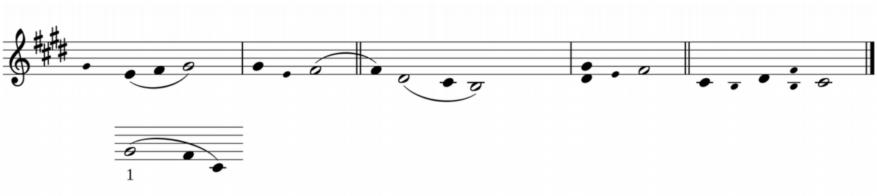

Figure 10. *Laosheng xipi* Yuanban opening line.

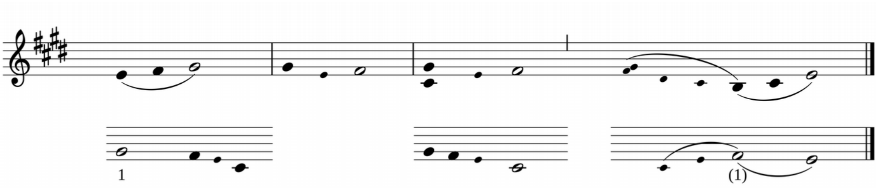

Figure 11. *Laosheng xipi* Yuanban closing line.

Xipi is contrastingly characterized for the symmetry of its melodic lines, even though the data from the JMSC show a more nuanced situation. Boundaries for S1 and S2, as respectively shown in Figure 10 and Figure 11 for O and C, are, differently from O2 and C in *erhuang*, clearly marked and, in terms of melodic content, both sections are almost identical. *Laosheng xipi yuanban* O and C are some of the few occasions where linguistic tones have a direct influence in the melodic structure. When a lyrics line starts with a tone 1 character, the melodic line starts with the structural pitch **3**, followed by a descending movement—this is marked by '1' in the alternative stave of Figures 10 y 11, the position of the number indicates the position of the tone 1 character. Otherwise, **3** is used as the cadencing degree for S1. A very interesting aspect of O is that it usually presents a short *tuoqiang* to conclude S2, which stresses **7̣** and cadences in **5̣**, showing some similarity with the *tuoqiang* of *laosheng erhuang yuanban* C (Figure 9), although with a simpler development here. When this *tuoqiang* is not performed, an empty measure is always maintained between S2 and S3, also in C. These two characteristics, the descending pattern used in S1 when lyrics start with a tone 1 character and the *tuoqiang* after S2 explain the appearance in Figure a5.6 of **6̣** and **5̣** as frequent cadential notes in respectively S1 and S2. The noticeable occurrence of **1** as cadential note for S2 in opening line is due to a common descending inflection of cadential **2**, which is usually notated as **21**, with **2** on the strong beat. Otherwise, the cadential notes **3** for S1 and **2** for S2 are clearly predominant, strengthening the boundaries of these two sections. These melodic boundaries, differently from the case of *laosheng erhuang yuanban*, align with and reinforce the corresponding lyrics boundaries.

The main differences between these two lines, in terms of melodic content, lie in section S3. Comparing Figures a2.14 and a2.15, it can be observed that sections S1 and S2 show a rather similar distribution of pitches, with a strong focus in **1**, **2**, and **3**. However, in S3 the balance changes, and while in O the central degree is **2**, in C is **1**, both of them being their respective cadential notes, as shown in Figure a5.6. This different balance of degrees between O and C results in an impact on the overall pitch space of the line, as shown in Figure a1.15, where **1** is the most frequent degree, while Figure a1.14 shows that the use of this degree in O is much more restricted. In some cases, O concludes with a *tuoqiang* cadencing on **6̣**. Figure a7.6 shows that these *tuoqiang* in opening line, both in S2 and S3, are relatively short.

O-S3 presents another interesting feature. Even though the common explanation of the metrical structure of both O and C establishes a caesura between S3.1 and S3.2, the data from the JMSC show that in the case of O this mostly happens when a *tuoqiang* follows. Out of the 23 lines of this category, this caesura is present in the 7 lines that concludes with the aforementioned *tuoqiang*. Among the remaining 16 lines, only 2 separates the last two characters of S3.2 with a short rest. This implies that in the majority of the lines S3's characters are sung without interruption in either one or two measures. That is why the melodic schema for opening line in Figure 10 presents S3 in one single unit. Another feature of this line section is its high melodic variability, so that only the cadential **2** can be understood as a structural pitch.

Contrastingly, C-S3 clearly shows a melodic caesura between S3.1 and S3.2 and presents a much better defined melodic motion. The most common shape of this motion in C-S3.1 is very similar to the one in the whole O-S3. Considering that, besides this fact, O-S3 is usually performed without interruption in one or two measures, as C-S3.1 does, the similarity between opening and closing lines to this point is remarkable. This might allow to understand both lines as sharing the same melodic outline, but with a concluding melodic addition in C, which forms its S3.2. To reinforce this idea, the melodic outline of this subsection is quite well defined and highly prominent across the analysed samples. A variant to this concluding phrase, shown in the extra stave in Figure 11, is commonly used when the final character belong to tone 1. In both cases however, the characteristic ascending pattern of three consecutive scale degrees, either as **5̣6̣1** or as **6̣12**, convey the concluding function. Finally, C-S3.1 occasionally takes the shape of the descending motion shown in the extra stave of Figure 11, which is very similar to the one used in S1 for initial tone 1 characters. However, in this case, there is no clear relation of this phrase with a particular tone category.

The differences between *erhuang* and *xipi* regarding *laosheng* Yuanban have been thoroughly pointed out in the previous discussion. As presented in Section 4.4, a common characteristic mentioned in the literature to differentiate *erhuang* and *xipi* is their intervallic preferences. The former is described as preferring conjunct steps (Wichmann 1991: 79, Zhang$_5$ 1992: 31, Cao 2010/1: 2), whilst the latter is described as making a more frequent use of larger intervals (Wichmann 1991: 79, Zhang$_5$ 1992: 445, “jingju” 1999: 431). However, Figures a3.9 and a3.10 show that the distribution of used intervals is quite similar. The major second is the most used interval in both cases, standing for a 49.1% in *erhuang* and 43.74% in *xipi*, followed by the minor third, whose percentage of the total is 22.27% in *erhuang*, and 23.03% in *xipi*. These are the natural intervals of the pentatonic scale, so it can be concluded that conjunct steps stand for 71.37% in *erhuang* and 66.77% in *xipi*. Considering larger intervals, the percentages for major third are 4.91% in *erhuang* and 5.88% in *xipi*, for perfect fourth are 5.8% in *erhuang* and 8.48% in *xipi*, and for perfect fifth are 2.4% in *erhuang* and 2.79% in *xipi*. Consequently, the tendency described in the literature is confirmed by these data. However, the difference between the two *shengqiang* is statistically minimal, showing that the overall intervallic character of *erhuang* and *xipi* is very similar.

Finally, the obtained results show an interesting difference between *erhuang* and *xipi* regarding melodic density. Looking at the average results in Tables a7.1 and a7.5, the median duration per sung syllable is one crotchet. However, the corresponding data in Tables a6.1 and a6.2, show that syllables in *xipi* are generally sung with 3 notes, while syllables in *erhuang* are generally sung with 2 notes. This difference is mostly motivated by the lower melodic density of *laosheng erhuang yuanban* O2 and C, since O1 presents also a melodic density of 3 notes (Table a6.2). This difference might suggest a more plain, and perhaps faster performance of *erhuang* O2 and C.

Dan erhuang and *xipi* Yuanban

Dan erhuang Yuanban's lines present the same metrical structure as their equivalent lines in male singing. O1 (Figure 12) shows the one and a half lines characteristic form, and indeed S2 and S3 consist in a very similar melodic phrase, stressing **7** at the beginning, descending through **6** and **5**, to then ascend to and cadence on **1̇**. An interesting characteristic of this line, compared with its equivalent in male singing, is that when the penultimate character belong to tone 1, it is sung in **2̇**, thus showing a consistent influence of linguistic tones in the melodic structure. A characteristic feature of female singing is a descending melodic inflection after the cadential note, generally to **6**, but taking the shape of **2̇7**—or just **2̇**—when it previously rises to **2̇** for a tone 1 character. Figure a5.7 shows how the cadential notes for S1 and S2 in O1, respectively **5** and **1̇**, are clearly established, thus strengthening the boundaries between line sections, and how in S3 cadential melodic inflections ending on **7** or **6** after stressing **1̇** in strong beat are the most frequent performance choice.

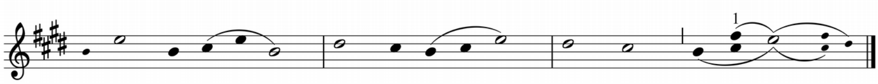

Figure 12. *Dan erhuang* Yuanban opening line 1

Both O2 and C (Figures 13 and 14) present the same metrical structure as their counterparts in male singing, in which the boundary between S1

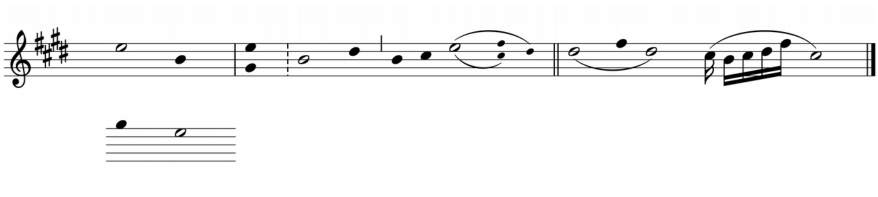

Figure 13. ***Dan erhuang*** **Yuanban opening line 2**

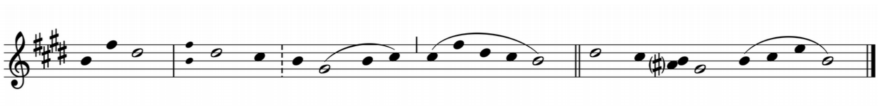

Figure 14. ***Dan erhuang*** **Yuanban closing line.**

and S2 is marked with a short rest, as it is the one between S3.1 and S3.2, while the boundary between S2 and S3 is lost within a continuous melody. Figure a5.7 shows how the boundary between S1 and S2 is more stable in *dan* for O2 and especially C, with a well established cadential note on **7**. Interestingly, the only two instances of concluding *tuoqiang* in the JMSC for *dan erhuang* Yuanban opening lines are found in O2 (Figure 13, samples 1 and 2 in Figure a6.10). Its overall melodic outline resembles that of its equivalent in male singing's O1 (Figure 7), but an octave higher. The *tuoqiang* begins sustaining **7** and cadences on **6**. The two samples in female singing show an identical melodic pattern to conclude, **6 5671̇ 6**.

The statistical information extracted about pitch brings to light interesting characteristics regarding the preferred pitch space. The use of the degree 'coloration tone' **7**—which does not belong to the pentatonic scale that predominates—although not at all in exclusivity, in jingju singing is highly significant. Comparing the pitch distribution of O2 and C, as respectively shown in Figures a1.18 and a1.19, a clear contrast is established in the use of either **7** or **1̇**. While in O2 **1̇** is one of the most frequent degrees and **7** has just a marginal use, C shows the opposite preference, with a very predominant use of **7**, and almost avoidance of **1̇**. This contrast is especially meaningful considering that O2 and C, taking Zhang$_5$'s terminology, are performed in a "connected" way, with very short instrumental interludes between them, if any. This contrasting pitch space would contribute to the establishment of each line type's identity. O1 shows an overall balanced use of both degrees, although certain specialization in line sections can be observed in Figure a2.17, since **7** is absent from S1, but as prominent as **1̇** in S2 and even more prominent in S3.

Tuoqiang in C (Figure 14) are characterized by their length (Figure a6.11), reaching even a string of 57 notes (Table a6.11). They show the same higher octave relationship with its counterpart in male singing, both sharing an overall melodic motion, which begins on **7**, descends to **3** and cadences on **5**. It is only in the cadence pitch of the *tuoqiang*, besides the already mentioned octave difference, that male and female singing coincide. Otherwise, the cadence pitch of female singing for C is **5** (Figure a5.7), whilst it is **2** in male singing.

This brings to attention the relationship between male and female singing, and the common assumption that the latter is derived from the former. The main element of agreement between the two styles is the cadential pitch class in opening lines, and in C only if male singing performs a *tuoqiang*. The computed pitch histograms show that the ambitus used in female singing (Figure a1.16) is exactly the transposition one octave higher of the male singing's one (Figure a1.9). The upwards shift of an octave would have created important challenges to the performers in order to reach the higher pitches, especially during the formation of the genre when most performers were male actors. There is a common saying in jingju circles which argues that women, that is, performers of female singing, dread *erhuang* (Wichmann 1991: 86), expressing the physical challenges of such a pitch range for performers. As a possible consequence, the pitch region above **1** used in male singing's O1 and C is not used, in its correspondent higher octave, in female singing, and as a consequence new melodic approaches are needed.

Besides the cadential pitch, opening lines in both male and female singing styles also share the common approach to this pitch from bellow in the usual concluding ascending motive of three consecutive scale degrees, in this case starting from **5** (or **5̣**). The predominance of **7̣** in male singing's O2 is not as high in its female counterpart, where it only appears in S3—or S2, considering the blurred boundaries. This pitch, **7**, has however a remarkable importance in female singing's O1, contrasting with its male version. As a result, female singing's opening lines are more similar to each other than in male singing. It can be argued that both shared resources to overcome the pitch range challenges.

Closing lines in both singing styles, even though they differ in the essential cadential pitch, show a closer similarity in the overall melodic motion. The predominance of **7** (**7̣**) from S2 is common to both styles, the structural pitch **2** in male singing's S1 is also usually performed in female singing. And in both cases the first subsection of S3 concludes with a **356** (**3̣5̣6̣**) movement. Even though the male singing's cadential pitch **2** is usually reached in its higher octave in female singing for the concluding melodic phrase, it is only part of a larger melodic motion cadencing on **5**, which can be explained as this pitch being more comfortable, and therefore more secure, to perform in such an important metrical position as the cadence of the whole couplet. The chose of this pitch might have been influenced by the cadential pitch of the *tuoqiang*.

Finally, female singing in *erhuang yuanban* presents the same melodic density than male singing in terms of notes (Table a6.8), but interestingly lower in terms of duration, being the median duration a quaver (Table a7.8), while in male singing is a crotchet (Table a7.1). This value of a quaver is the predominant in O2 and C, lines which proportionally are more used than in male singing. The generally slower tempo in performance for female singing might explain the trend of singing the syllables of each line section in a more comprised rhythmic manner. On the other hand, regarding the intervallic space, the general trends between male and female singing are very similar, with a predominance of major seconds and minor thirds, which jointly account for a 71,84% (Table a3.11, also for following data), while in male singing account for a 71.37%. (Table a3.9, also for following data). However, the more noticeable difference is the more frequent use of perfect fourths. If in male singing they stand for the 5.8%, in female singing their percentage reaches 11.32%, almost double. Looking at the data about directed intervals (Table a4.11), descending perfect fourths are more frequent (6.7%) than ascending ones (4.61%). This might be due to the characteristic descending movement from **1̇** to **5** found in the S1 of both O1 and O2.

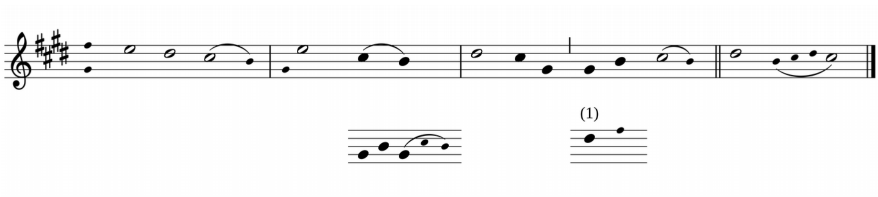

Figure 15. ***Dan xipi*** **Yuanban opening line**

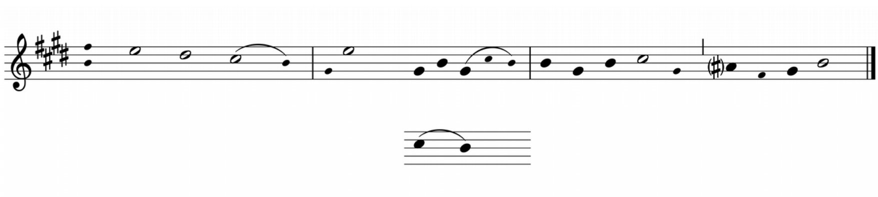

Figure 16. ***Dan xipi*** **Yuanban closing line.**

Dan xipi Yuanban's O and C clearly illustrate the symmetrical structure that characterizes *xipi*, even more accurately than in male singing. As Figures 15 and 16 respectively show, S1 and S2 present the same melodic motion. S2 presents two possible concluding phrases descending from the common $\dot{1}$, firstly **65**, which reminds S1's conclusion, and secondly **353**, which occasionally also adds the **65** cell, conferring it a clear concluding function. The only difference between O and C is the major occurrence of one of these phrases over the other in the analysed data.

If the similarity of S1 and S2 between O and C is common to the male style, there also some differences. The common *tuoqiang* after S2 in male singing's O is not to be found in female style. The instrumental measure between S2 and S3 is maintained in female singing, but only in opening lines. The boundary between S2 and S3 in female singing's C is usually not marked by a rest, but by the consistent metrical position of the characters, which groups S2's characters in its first half, distancing them from the start of S3. Besides, the concluding cell **65** reinforces the boundary.

Figure a5.8 shows a striking predominance of **5** as cadential note in every section of both O and C. This degree, however, should be only considered as cadential note of closing line's S3 (Figure 16), according to the reviewed literature. Regarding S1 and S2 from both opening and closing lines, but also O-S3, this **5** usually refers to the second note of the **65** cell, of which it is **6** the note that lies on strong beat. Therefore, instead of a cadential note, it is this cell the one expressing a cadential function in these two sections. Finally, even though the preferred cadential note of opening line's S3 is **6**, the degree **5** still is highly recurrent (respectively 47.06% and 44.12% of the total, Table a5.8). In this case, the high occurrence of **6** in this position is due to the frequent *tuoqiang* cadences on this degree. According to its melodic motion, this *tuoqiang* might be borrowed from *laosheng xipi* Yuanban O (Figure 10), since in both cases **7** (7̣) is first established to later move to the cadencing **6** (6̣). This *tuoqiang* is highly frequent (see Figure a6.13), and with a very variable length, from 8 notes to 45 (Table a6.13).

Another difference with male singing is that S3 in both O and C present the same metrical structure, with a consistent caesura between its two subsections. The melodic line in S3 is what sets apart female singing's O and C. In the former, there is a clear movement from a structural **7** at the beginning of S3 towards a cadential **6**, going through a medial **3** (Figure 15). In C, two phrases with an inverted arch shape leads to the structural pitches **6**, which concludes the first subsection, and the cadential **5**. In this last phrase, the 'coloration tone' **4** is commonly used, notated by some transcribers as **♯4** (Figure a1.22). The general pitch space in S3 in each line also shows important differences, as can be observed in Figure a2.21 for O and Figure a2.22 for C. The predominant degree in O-S3 is **6**, while in C-S3 the most frequent degree is **5**. On the other hand, if **7** is a relevant degree in O-S3, it is barely sung in C-S3. Interestingly, **1̇** is practically absent in both lines' S3. These differences in S3, even though the pitch distribution in S1 and S2 for both lines is quite similar, have a general impact in the pitch space of the whole line, as can be observed in Figures a1.21 and a1.22 respectively for O and C.

An outstanding difference between male and female singing in *xipi* Yuanban is that female singing's lines are much more consistent in their melodic surface than those of male singing, where they show a high degree of variability. And indeed, it is the melodic schema itself the major difference between male and female singing. Female singing's lines show a very characteristic descending phrase in S1, containing a remarkably distinctive semitone between 1̇ and **7**, which is nowhere to be found in male singing. If in male singing structural pitches in S1 and S2 show a descending relationship, in female singing S2 goes back to the initial pitch of the characteristic phrase, 1̇, and generally concludes with the same melodic cell **65**. Melodic lines in S3 are freer in surface than in S1 and S2, but still more consistent than in male singing. The use of **(♯)4** is also very characteristic. The only ostensible similarity between male and female singing could arguably be the descending major second relation between the structural notes of closing line's S3, **2**–**1** in male singing, and **6**–**5** in female singing. To these facts it has to be added the convention of transcribing, and also performing, *dan xipi yuanban* in 4/4 metre, being the only rendition of *yuanban* not conceived in 2/4 metre. These striking differences would support Hai Zhen's claims that male and female singing in *xipi* stem from different preexisting *shengqiang* (Section 4.4).

Finally, regarding melodic density, even though female singing is usually transcribed in a larger metre than male singing, and sung in a slower tempo, in both cases a syllable is generally sung with three notes (respectively Tables a6.12 and a6.5), even though in female singing they take one crotchet and a half, versus a single crotchet in male singing (respectively Tables a7.12 and a7.5). In terms of the intervallic structure, female singing shows similar trends as male singing. Conjunct steps, including both major seconds and minor thirds, are the preferred intervals, accounting for a 69.64% in female singing (Table a3.12), and a 66.77% in male singing (Table a3.10). An interesting fact is the use of minor sixths in female singing (3.02% in female singing, versus 0.1% in male singing), which might point out to the ascending or descending movement between **3** and 1̇, especially frequent in S2.

According to the common assumption in state of the art literature, all the *banshi* in the jingju musical system stem from *yuanban*. Therefore, in the following presentation of the remaining melodic schemata I will focus on their relationship with the corresponding schema in *yuaban*. The aim is to observe plausible explanations for the derivation of these *banshi* from their corresponding *yuanban* counterparts.

Laosheng erhuang and *xipi* Manban

The most ostensible conclusion when comparing *laosheng erhuang* Manban's lines with their corresponding Yuanban versions is a higher degree of melodic complexity, as a result of the slower tempo and the broader metre, and a tendency to expand the pitch space towards lower regions, as observed when comparing Figures a1.9 for Yuanban and a1.23 for Manban. These characteristics show that the changes in tempo and metre do not result in a mere slower rendition of Yuanban's melody, but that it has profound implications to its melodic structure.

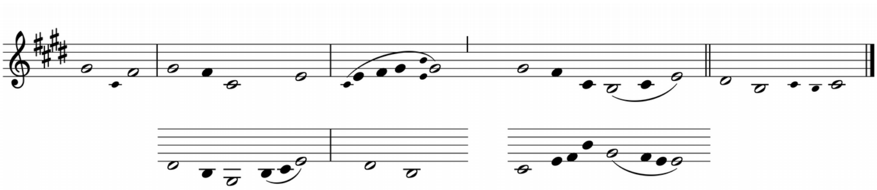

Figure 17. *Laosheng erhuang* Manban opening line 1.

O1 (Figure 17) in *laosheng erhuang* Manban shares the structural notes in each section with its Yuanban counterpart, and even the melodic motions to reach them, although with new additions that enrich the melodic progression. This increase in complexity is especially ostensible in S3, and even more in its second subsection. The degree 7̣ founds in this line a structural relevance that did not have in its Yuanban counterpart, even though quantitatively the difference is not substantial (only an increment of 1.66 in its percentage is observed, Tables a1.9 and a1.23). These new developments, besides the fact that the performer has now more space for exploring larger pitch regions, could be understood as the influence of melodic phrases from O2 or C, where 7̣ plays a relevant role. O1's *tuoqiang* in Manban presents the same structural pitches as in Yuanban, even though they are much longer, with several cases over 40 notes and one reaching 59 (Figure and Table a6.16). This can be explained by the fact that the new tempo and metre allows the performer a freer and more complex development of its basic melodic schema.

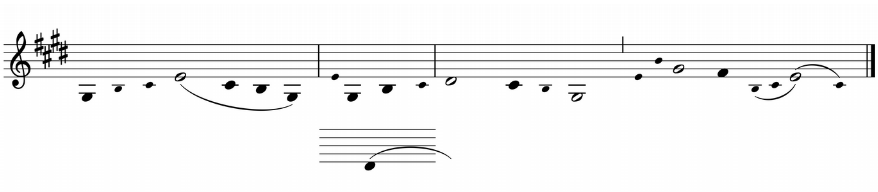

Figure 18. *Laosheng erhuang* Manban opening line 2.

The situation of O2 (Figure 18) is the same as O1. Compared with its Yuanban counterpart, the Manban version is more complex, especially in S3.2, and reaches lower pitch regions. Besides these, there are other two important differences to consider. Firstly, boundaries between sections are now frequently marked with a short rest. This circumstance however do not imply that the melodic identity of each section is fixed. This is especially the case of the boundary between S2 and S3.1. Even though in the surface it is marked with a rest, the melodic inner motion is fluent across it. The high variety of degrees appearing at the end of these sections, as shown in Figure a5.9, confirms that this position is not conceived as a resting point. This means that the pitch 7̣, which is the goal of a melodic motion which starts in S2, is frequently established in S3, but can be also reached in S2. In this case, the descending motion towards 3̣ can start already at S2, or 7̣ be prolonged or reapproached in S3. The second noticeable difference is the absence of 7̣ in S1 (Figure a2.25), where in Yuanban it holds an essential position (Figure a2.11). Instead, the pitch 1 occupies a central position, commonly approached from 3̣, to which it returns in order to ascend again towards 7̣. This melodic phrase in S1 is more intriguing, since not clear correspondence can be found in other *laosheng erhuang* Manban lines. This might raise the question whether this structural pitch 1 points to a common characteristic of *erhuang* O2, which at some point was abandoned before the establishment of *yuanban*'s O2 in the form it has been transmitted to us.

Laosheng erhuang Manban C (Figure 19) presents the same characteristics as O2 when compared with its Yuanban counterpart. The melodic

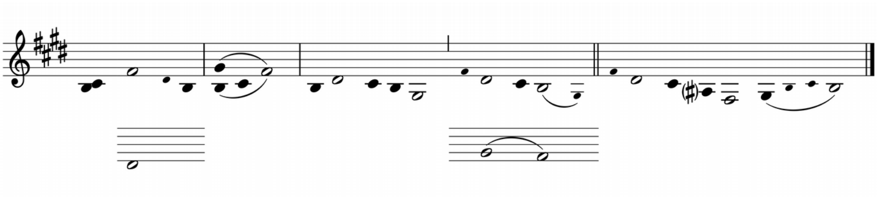

Figure 19. *Laosheng erhuang* Manban closing line.

schema is more complex, especially in S3, lower pitch regions are reached, as can be observed in the comparison of Figures a2.12 and a2.26, and the boundaries between sections are marked with a short rest, although in this case the melodic phrase of each section is quite fixed. The structural notes that characterize the first half of the line are shared both in Yuanban and Manban, maintaining hence the structural motion **2** – **7̣**. However, the pitch **7̣**, which in Yuanban is usually established in S2, in Manban is not consolidated until S3, extending thus the predominance of **2** to S2. The most interesting difference though is the frequent use of a concluding phrase in the second subsection of S3 that cadences on **5̣**, usually followed by a descending ornament towards **3̣**, and which appears in more occasions than the common cadence on **2** used in Yuanban and commonly agreed in the literature as characteristic of *erhuang* C. In fact, as shown in Figure a5.9, this degree is used as cadential in a minimal percentage of cases, just 11.54% (Table a5.9). The use of this descending phrase cadencing on **5̣** can be explained as the influence of *tuoqiang*, which presents a similar, but more complex melodic motion than the one used in Yuanban (Figure 9). If very rarely *tuoqiang* in Yuanban present more than 20 notes, in Manban is frequent to reach more than 30 (Table a6.18). On the other hand, this cadencing phrase on **5̣** also resembles the one used in *dan erhuang* Yuanban C (Figure 14). When discussing this line, the question arose about its origin, considering its male singing version as the proposed source. If in the case of *laosheng erhuang* Manban O2 the novelty of S1's melodic phrase invites to think of a preliminary common melodic schema, this situation could also point to the possibility of a previous *erhuang* closing line on **5̣**, which would explain its female singing rendition as a consistent shift to the higher octave also in C.

As expected from the melodic enrichment that characterizes Manban in relation with Yuanban, its average melodic density increases, but only in one note, namely 3 notes per syllable, versus 2 in Yuanban (respectively Tables a6.15 and a6.1). If the melodic density is considered in terms of duration, the same value of a crotchet is shared by both Yuanban and Manban (Tables a6.1 and a6.15). The slower tempo in Manban allows for the performance of more notes in the same metrical unit. Regarding the intervallic space (Figure a3.13), besides small changes in the proportion of several interval classes, no significant changes are appreciable in comparison with Yuanban (Figure a3.9).

For the analysis of *laosheng xipi* Manban it has firstly to be noted the small number of samples available in JMSC, specifically 21 for opening line, and 19 for closing line (Table 15). These lines belong to just three different arias, for two of which two versions from different sources are included, so that the number of unique lines is even smaller, respectively 13 and 11 (although, as described in Section 4.1, different scores for the same aria are never identical). Therefore the results here presented might be at risk of overfitting. On the other hand, a noticeable characteristic of these lines is a great variability in melodic surface, even within the same aria. Notwithstanding this, even though the melodic motion presented in the following schemata might show divergences in the actual aria lines, the structural pitches are however shared across them.

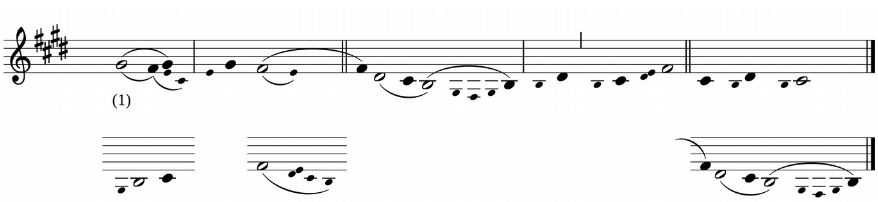

Figure 20. *Laosheng xipi* Manban opening line.

Laosheng xipi Manban lines present the same characteristics as in *erhuang*. When compared with their Yuanban counterparts, these lines also show a higher degree of complexity, especially in S3, and a tendency to explore lower pitch regions, even more pronounced than in *erhuang*, as is clearly ostensible from the comparison of Figures a1.13 for Yuanban and a1.27 for Manban. In the case of O (Figure 20), the caesura between S3.1

and S3.2 is now clearly established in all the instances from the JMSC. Besides these phenomena, O maintains the same structural pitches as its Yuanban version, as well as the peculiar structure with a *tuoqiang* after S2. The aforementioned variability of these lines is especially ostensible here in the concluding formulae. The *tuoqiang* already described for its Yuanban analogue (Figure 10) is present here, but there are also uses of a new *tuoqiang*, cadencing on 5̣, which resembles in its melodic shape the one commonly used in *erhuang* C, and therefore they could be understood as borrowed here. Interestingly, both *erhuang* C and *xipi* O are described in literature as cadencing on 2. Therefore, this might suggest a perceived relationship between this cadence and a specific *tuoqiang* associated to it. In both cases, these *tuoqiang* are much lengthier than the ones used in Yuanban (Figure a6.20), usually longer than 30 notes, and even closer to 40 (Table a6.20). Besides these two *tuoqiang*, the analysed data also present instances of a melodic extension, even though much shorter than the *tuoqiang*, of the concluding melodic phrase, but still cadencing on 2. Since these cases do not show a common structure, I have considered then as an occasional prolongation of the cadential phrase. Having these facts into account, the schema of cadential notes for Manban (Figure a5.10) shows the use of the same degrees as in Yuanban (Figure a5.6), but with a remarkable increase of those below 1.

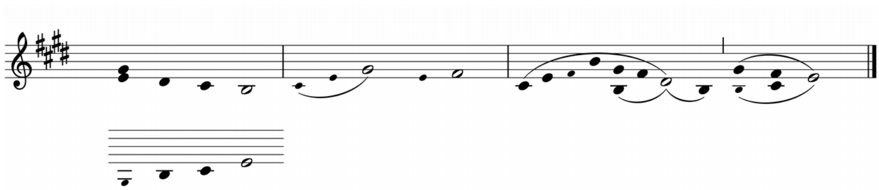

Figure 21. *Laosheng xipi* Manban closing line.

Laosheng xipi Manban C (Figure 21) presents the same characteristics of richer melodic complexity and a very pronounced tendency towards lower pitch regions (Figure a1.29, in comparison with Figure a1.15). This tendency is especially ostensible in S1, as shown in Figure a2.29 (its Yuanban equivalent can be seen in Figure a2.15). This Figure also shows the loss of importance of degree 2 in S3, which looking at Figure 21 can be more specifically localized in S3.1. In turn, 7̣ gains an essential predominance, even though it is not reflected in the mentioned figure, since the predominance of the cadential degree 1 might reduce its relative occurrence. The importance of this degree in this line position might point to an influence of *erhuang* Manban O2 and C, whose S3.1 also show a structural role of this 7̣ degree.

When compared with their Yuanban analogues, Manban lines keep the same average melodic density of three notes (Table a6.19), but increasing the average duration for singing a syllable from one to two crotchets (Table a7.19), indicating a clear influence of the metre expansion from 2/4 to 4/4. Regarding the intervallic space, Manban shows an important increase of conjunct steps, 74.29% (Table a3.14) versus 66.77% in Yuanban (Table a3.10).

Both the second *tuoqiang* described for O, or the importance of 7̣ in S3.1 in C might point to an influence of *erhuang* in these lines. And this might have a functional motivation. As described in Sections 4.4 and 4.5, both *shengqiang* and *banshi* are associated with expressive functions. *Manban* is commonly used for the expression of inner, deep, profound emotions in a reflective, intense manner. This function is closer to the one associated to *erhuang* than the one associated to *xipi*, which is used for creating an energetic, forceful emotional atmosphere. Therefore, *xipi maban*, even though within the scope of *xipi*'s emotional atmosphere, leans towards *erhuang*'s expressive function. Consequently, it would seem a useful resource to strengthen *manban*'s expressive function to borrow melodic elements from *erhuang*, such as the use of the 'coloration tone' 7̣ or a characteristic *tuoqiang*.

***Dan erhuang* and *xipi* Manban**

The same general trends described in the previous section when male singing's Manban lines where compared with their Yuanban relatives, are also to be found in female singing. Firstly, their melodic schemata become much more complex. This is due to the same reason as in male singing, namely the longer space the actor or actress has for enriching the melody thanks to the slower tempo and the broader metre. However, it is also due to the fact, as already noted, that female singing lines are more regular and consistent than male singing ones. Therefore, it is possible for the schemata to reflect melodic motions in greater detail. Regarding the use of lower pitch regions, here it is also the case, not in the sense that the pitch range has broadened, since it is largely the same, but in the sense that the lower spectrum of the range is more frequented, even though in a more limited manner than their male singing counterparts. The comparison of Figures a1.16 for Yuanban and a1.30 for Manban shows how the degrees **5**, **6** and especially **3** are more frequently used in the latter than in the former, at expense of degrees **7**, **1̇**, **2̇** and **3̇**.

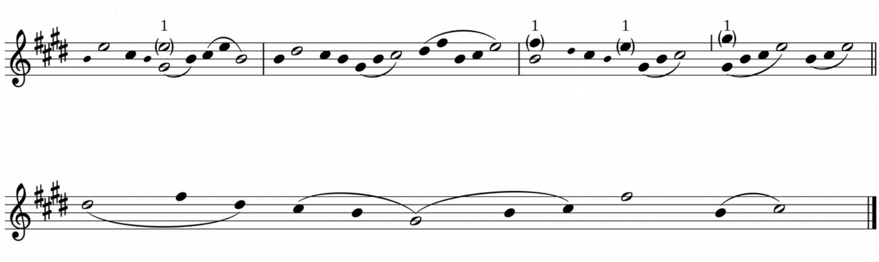

Figure 22. ***Dan erhuang*** **Manban opening line 1.**

Dan erhuang Manban O1 (Figure 22) is a clear example of the gain in complexity, since most of its Yuanban analogue's structural pitches and motions are here maintained and enriched, but also of the regularity of these lines, which allows the construction of very detailed melodic schemata. It is worth noting how certain pitches in different sections are dedicated to the singing of tone 1 characters, being this case the one showing the most explicit influence of tone categories on melody. In terms of melodic structure, the most interesting element however is the very common use of *tuoqiang*—shown in Figure 22's second stave just for better readability—, an element that is not used in its Yuanban analogue. This *tuoqiang* might be borrowed from O2 (Figure 13), whose melodic contour shows important similarities with this one. Since both are opening lines, its use in either of these lines will still contribute to keeping the couplet structure. Noticeable differences between the *tuoqiang* in Yuanban O2 and Manban O1 are that the latter is used much more frequently (Figure a6.23) and that it can be remarkably lengthy, frequently over 50 notes (Table a6.23). The high frequency in the use of this *tuoqiang* can be observed in the schema of cadential notes (Figure a5.11), where the cadential note established by this *tuoqiang*, **6**, stands for 69.23% of the total (Table a5.11).

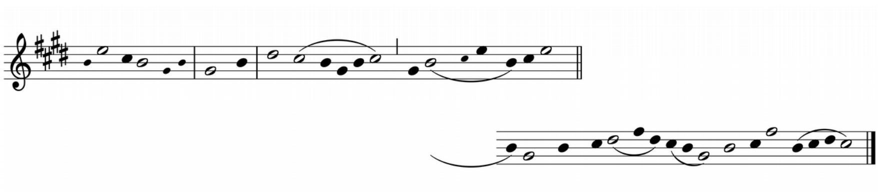

Figure 23. ***Dan erhuang*** **Manban opening line 2.**

A peculiar characteristic of the *tuoqiang* in Manban O2 (Figure 23), is that it is approached from **5**, a different pitch from the one used for standard cadence, **1̇**. Compared with the *tuoqiang* used in O1, this one is less frequently used (Figure a6.24), but when used, they can reach the same lengths over 50 notes, even arriving at 70 notes (Table a6.24). Besides this particularity, as in the case of *laosheng erhuang* Manban O2, its female singing analogue, when compared with its Yuanban counterpart, shows a more defined establishment of the boundaries between all sections. In particular, the boundary between S2 and S3, which is the less defined one in Yuanban, now is usually marked with short rests and strengthened with a more regular schema of cadential notes (Figure a5.11).

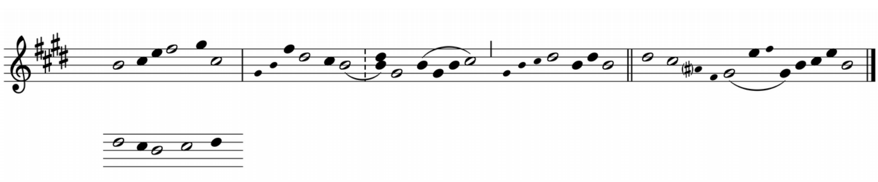

Figure 24. ***Dan erhuang*** **Manban closing line.**

In the case of C (Figure 24), the boundary between S2 and S3 it is also frequently marked with a short rest. However, the structural pitches showed in Figure 24 can still occur before or after that position, thus blurring its structural function. When analysing *laosheng erhuang* Manban O2 (Figure 18), I pointed out that, compared with its Yuanban relative (Figure 8), the degree **7̣** that is in the latter established in S1 and prolonged in S2, is in the former not consolidated until S2, presenting a new melodic phrase for S1. In the case of *dan erhuang* Manban C, even though some lines begin S1 by establishing **7**, as shown in the extra stave in Figure 24, more lines use a different melodic phrase for S1, so that **7** is not established until S2. The comparison of Figures a2.19 for Yuanban and a2.33 for Manban shows a remarkable decrease in the use of **7**, especially in S1. As in the case of the male singing lines, this might point out to a previous melodic phrase, no longer used in Yuanban.

Notwithstanding the differences between the Yuanban and Manban lines for *dan erhuang* previously described, the similarity between the two *banshi* groups in terms of melodic motion is much higher than between the analogue ones in male singing. In spite of the already pointed out increase in the use of the lower degrees of the pitch space, the comparison of Figures a1.16 for Yuanban and a1.30 for Manban also shows how in both *banshi* groups the overall pitch distribution is generally shared, with **5** and **6** as clearly predominant degrees over **3**, **7**, **1̇** and **2̇**. The intervallic space do not show significant differences either, as it can be observed by contrasting Figures a3.15 and a3.11. On the other hand, the effect of the slower tempo and broader metre in Manban does have an important impact on its melodic density, whose average value is 4 notes per syllable (Table a6.22), thus doubling the melodic density of Yuanban (Table a6.8). This value is specially high in O1, reaching even 11 notes per syllable in one case. These data, even though they should be related to the degree of detail of the particular notation, are an indicator of the grade of richness and nuance of *dan erhuang* Manban's singing.

When analyzing *dan xipi* Yuanban lines, I pointed out the consistency and regularity of their melodic outlines as a particular characteristic. Their Manban relatives maintain this characteristic, and as in the Manban lines described so far, these also show a gain in melodic complexity. Regarding O (Figure 25), the only special characteristic to comment is that occasion-

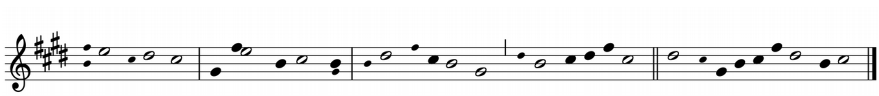

Figure 25. *Dan xipi* Manban opening line.

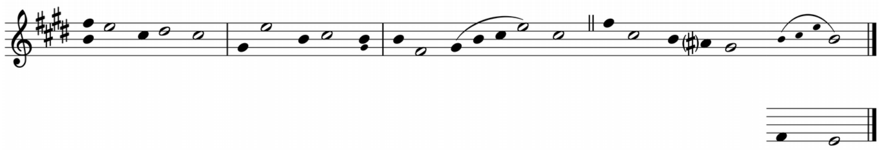

Figure 26. *Dan xipi* Manban closing line.

ally the structural pitch $\dot{1}$ in S2 is replaced by $\dot{2}$. However, $\dot{1}$ arguably keeps its structural value, as it appears in most of the analysed lines, and it holds the same function in its Yuanban relative.

C (Figure 26) shows the same characteristic of gaining melodic complexity when compared with its Yuanban relative, maintaining the overall melodic motion. Besides this general, already discussed characteristic, C shows two interesting further features. Firstly, except for one single case, all lines conclude with a *tuoqiang*. Differently from previous cases, the melodic outline of this *tuoqiang* starts developing from S3.2. Therefore, this subsection joins the *tuoqiang*, so that it can not be distinguished from it. Figure 26 represents this circumstance with a double bar tick. Secondly, even though most of the *tuoqiang* cadence on **5** there also several cases (9 out of 24) in which after reaching the common medial turning pitch **3**, it continues to cadence on **1**, thus agreeing with male singing. Figure a5.12 shows the frequency of this last option, standing for a 36% of the overall cadential notes (Table a5.12).

Figure a5.12 shows another interesting trend. Compared with its Yuanban equivalent (Figure a5.8) **6** is much more frequently used as a cadential note than **5**. As mentioned during the description of Yuanban, the high presence of **5** in Yuanban's schema of cadential notes was due to the use of the melodic cell **65** as cadential unit, being **6** the main note, which falls on strong beat, and **5** the indication of a descending melodic inflection. The decrease of **5** in Manban's cadential schema indicates that this descending inflection has lost relevance here as cadential melodic cell, and **6** is confirmed as the main cadential note. On the other hand, and similarly to the case of *dan erhuang* Manban, these lines also show an increase in average melodic density, from 3 notes in Yuanban to 4 notes here (Table a6.26). Finally, regarding the intervallic space, an increase in the use of conjunct intervals is found, presenting a 73% in Manban versus 69,94% in Yuanban (respectively Tables a3.16 and a3.12), strengthened by the increase of major seconds, from 41.51% in Yuanban to 47.96% in Manban, at the expenses of the minor thirds, which decrease from a 28.13% to a 25.04%.

Laosheng and *dan xipi* Kuaiban

The two most outstanding and relevant characteristics of Kuaiban lines are, firstly, their enormous variability, which, combined with the fact that because of their fast tempo and tight meter their duration is remarkably short, results on quite unique realizations in every case, and secondly, that, for the same reasons, boundaries between sections are usually not marked, and the whole line can be sung in many cases in a single breath. This second characteristic can be confirmed by Figure a5.13, where the high variety of cadential notes in S1 and S2 in both O and C suggest that this position is not conceived as a structural resting point. Consequently, the melodic schemata here described present a unique melodic line, whose actual realization in surface might be greatly varied, what implies that structural pitches might be established in different line sections each time.

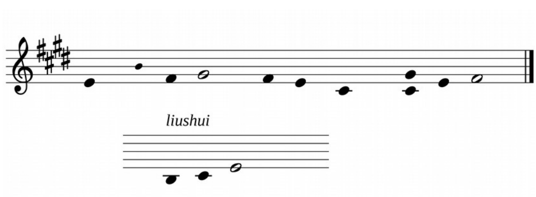

Figure 27. *Laosheng xipi* Kuaiban opening line.

Laosheng's O (Figure 27) shows the general outline that characterizes its Yuanban relative (Figure 10) from **3** to **2**, joint by a motion in the shape of an inverted arch, and with **3** approached from below. The comparison of Figures a1.14, for Yuanban O, and a1.38, for Kuaiban O, shows that the clear predominance in the former of the cadencing degree **2** is in the latter much less prominent (32.62% versus 25.27%, Tables a1.14 and a1.38).

Kuaiban O shows a much more balanced use of the three main degrees, **1**, **2** and **3**, which together with **6̣** form the core pitch space of this line.

The Kuaiban *banshi* group, as described in 7.1, contains lines from both *kuaiban* and *liushui*. In most of the lines belonging to the latter, a recurrent melodic cell is present, **5̣6̣1**, which although presenting the already discussed ascending pattern of three consecutive scale degrees, in this case is not used with a conclusive function, since it appears frequently, and in many occasions repeated, in central positions of the line. When compared with its Yuanban counterpart, a noticeable difference is the absence of *tuoqiang*. In fact, the analysed data from the JMSC only show one case (Figure a6.30) of a very long *tuoqiang*—for which the collection contains two versions—of 48 notes (Table a6.30). Being an isolated case, it might be considered as an exception rather than a rule, and therefore it has been excluded from the schema. The melodic outline of this *tuoqiang* is very close to the one used in *laosheng erhuang* C (Figures 9 and 19), even including the distinctive **4̣**, and cadencing on **5̣**. Previously, it was argued that the use in *laosheng xipi* Manban O of the *tuoqiang* from *Laosheng erhuang* C might be motivated by the fact that both cases share the same cadencing note. This might be also the motivation here, since the common cadencing note in both cases is **2**. As a consequence, this might indicate a specialization of certain *tuoqing* for specific cadential notes.

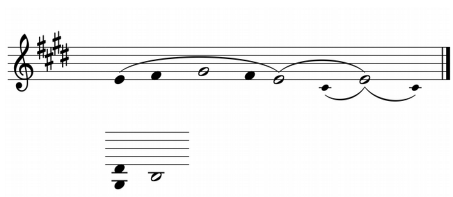

Figure 28. *Laosheng xipi* Kuaiban closing line.

The situation of *laosheng xipi* Kuaiban C (Figure 28) is very straightforward, since it consists in a simplification of its Yuanban relative, maintaining the basic melodic motion from **3** to **1**, but with a great level of variability on surface. The only peculiarity of this line is a frequent beginning in the lower pitch region, with focus on **5̣** and a distinct use of **7̣**, showed in the extra stave of Figure 28. This special phrase, not very common in its Yuanban relative, could be borrowed from the Manban counterpart, a fact that might point out to a common use of this pitches for *laosheng xipi* C, that didn't crystallized in Yuanban. Besides these characteristics, Figure a1.39 shows a remarkable increase in the use of **6̣** and **1**, at the expense of **2** and **3**. The high frequency in use of the degree **1** confirms its structural relevance as showed in Figure 28.

As expected from the increase in tempo and metre compression that characterize Kuaiban, the average melodic density is reduced from 3 notes per syllable in Yuanban to 1 note per syllable (Table a6.29), even though the average length of each syllable remains one crotchet (Table a7.29). In terms of intervallic space, Kuaiban shows similar general trends when compared with Yuanban (respectively Figures a3.17 and a3.10), with a predominance of conjunct intervals, 66.77% in Yuanban and 66.88% in Kuaiban, although an increase of minor thirds (from 23.03% to 26.26%) at expense of major seconds (from 43.74% to 40.62%) is observed. The most remarkable change is the increase of perfect fifths, from 2.79% to 4.21%, even though this interval remains a marginal one in terms of usage.

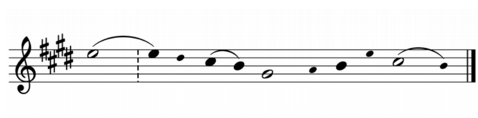

Figure 29. *Dan xipi* Kuaiban opening line.

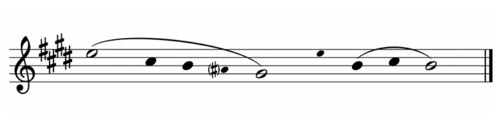

Figure 30. *Dan xipi* Kuaiban closing line.

Dan xipi lines, both in Yuanban and Manban, are characterized for keeping a rather consistent and identifiable melodic contour. In the case of Kuaiban, this contour is much more simplified, but the general motion from those previous *banshi* groups can still be identified. This simplification is also ostensible in the comparison of Figures a1.20 for Yuanban and a1.40 for Kuaiban. Even though the most frequent degree is **5**, its predominance increases in the latter, raising from 24.26% to 30.31% (Tables a1.20 and a1.40). However, the most significant difference is the almost avoidance of **7**, which decreases from 10.11% to 2.17%. This is highly relevant because it affects the very distinctive phrase of Yuanban's and Manban's S1, characterised by the use of **7** and the resulting minor second step formed with 1̇, which are now missing in Kuaiban, as can be observed in Figures a2.41 and a2.42 respectively for O and C. Consequently, the core pitch space, as in the case of the male singing counterpart, consists mainly of four degrees, in this case **3**, **5**, **6** and 1̇ (Figure a2.40).

The characteristic symmetry of *xipi* lines is maintained, and ostensible when comparing O (Figure 29) and C (Figure 30). Both start by establishing 1̇, then descend to **3** and ascend again to cadence respectively on **5** and **6**. *Dan* opening line is the only Kuaiban line in which a boundary, that between S1 and S2, is marked with certain consistency. The opening melodic phrase, starting in 1̇ and resting on the previously discussed cell **65**, can be performed entirely in S1, started in S1 and concluded in S2, or repeated in both sections, therefore stating the unstable character of this boundary. As in the case of *laosheng xipi* Kuaiban O, among the samples from the JMSC of its female singing analogue there is one single case of *tuoqiang* (for which there also are two versions, of 27 and 31 notes, Table a6.33), which should be again considered as an exception (Figure a6.33). This long *tuoqiang* starts rising to 1̇ from the cadencing note **5**, and from that traces a slow, ornamented descending movement in quavers through each scale degree, including **7** and **4**, to cadence on the male singing *xipi* opening line's prototypical cadential note **2**. To reach this end, a faster, wider movement in semiquavers is performed, finishing with the characteristic phrase **2 1235 2**. This phrase is identical, but a fifth lower, to the cadential phrase of *dan erhuang* Yuanban O2 (Figure 13), **6 5672̇ 6**, evidencing the frequent borrowing of melodic material across line categories.

As in the case of its male singing counterpart, the average melodic density of *dan xipi* Kuaiban lines is reduced from 3 notes per syllable in Yuanban to 1 (Table a6.32), as well as the average duration from 1.5 crotchets to just 1 (Table a7.32). In general trends, the intervallic space of Kuaiban is similar to Yuanban, even though interesting differences are found. The percentage of major seconds is notably reduced from 41.51% in Yuanban to 35.91% in Kuaiban, a difference that is gained by perfect fourths, which increase from 9.21% to 11.9% and by unisons, which raise from 10.7% to 14.5% (Tables a3.12 for Yuanban and a3.18 for Kuaiban).

7.4. Conclusions: jingju *shengqiang* melodic identity

In the previous section, I presented the results of the comparative analysis for each of the 24 line categories considered for study. As described in Section 7.1, each category results of the combination of the instances of the four elements of the jingju musical system, namely role type, *erhuang*, *banshi* and line type. However, the goal of this research is to reach a better understanding of *shengqiang* in terms of its melodic identity. To that aim, I propose here melodic schemata for the representation of *erhuang* and *xipi*. Since, as discussed in Section 7.1, the melodic unit is assumed to be the couplet, each schema aims at representing this unit for each *shengqiang*. Therefore, they contain a representation of each line type, namely O1, O2 and C for *erhuang*, and O and C for *xipi*. The schema of each line per *shengqiang* is obtained by comparing their instances across *banshi* group according to the following criteria.

First, the goal is to obtain a single line representation for each line category, that is, without the alternatives frequently offered in extra staves for the schemata in the previous section. The very nature of these alternatives deserves some discussion. It seems obvious that for most of the line categories previously analysed, the data show that performers draw on more than one underlying ideas for arranging a melody. Naturally, a direct factor for such variability unquestionably is the performer's own creativity, which gives him or her the freedom of diverging from the expected structure. However, even though in some cases the variability shown in the data is high, specially in *laosheng* Manban lines, there still is a limited number of identifiable patterns. This points towards the formulaic nature of jingju music arrangement, or jingju art in general, as explained by Stock (1999: 187). Indeed, during the previous discussion, many questions have been raised about the possible borrowing of certain factors across role types, *shengqiang* and *banshi* groups. In one of his last lessons, Shen *laoshi*, describing the techniques of jingju music composition, mentioned that one of the most distinctive characteristics is in fact 一腔多用 *yi qiang duo yong*, which can be understood as 'one [motive of] singing [melody] has many uses.’ This claim by even contemporary composers, for whom originality is a desired goal, shows the strength of this formulaic character. Zhang$_5$ Zhengzhi also points out a historical factor, and claims that during the long coexistence on stage of *erhuang* and *xipi*, they have both influenced each other, creating a “common melodic model” (共同旋律型 *gongtong xuanlü xing*), which the author studies in detail (Zhang$_5$ 1994a, 1994b, 1994c). Consequently, the melodic alternatives described in the extra staves of the previously analysed melodic schemata might be the result of such borrowing and reuse of melodic figures that are assumed as common to the jingju musical language.

In order to extract a single melody from the comparison of the previous melodic schemata across *banshi* groups, I focused first in the structural pitches. Those that appear in all instances are maintained also with the same structural level in the *shengqiang* melodic schemata here presented. If a structural pitch appears only in one *banshi* group, and also in others but as directional pitch, it is reflected in the new schemata with this last structural level. Finally, those directional pitches shared across *banshi* groups are also maintained in the schemata here presented as optional pitches (small noteheads). For the few exceptions where more than one single melodic motion is present in the schemata, the reasons will be explained accordingly. Since the focus is on *shengqiang* melodic identity, *tuoqiang* are not included. As described in the previous sections, *tuoqiang* is an expressive resource whose use is not universal, since for each line category there are samples without *shengqiang*, and they also vary in each *banshi* group, indicating that might be closer to this element than to *shengqiang*.

Finally, an important remark should be made regarding role types. The comparative analysis has been also applied of line categories across role types. However, no common melodic lines were found with enough consistency as to be claimed to underlie male and female singing. Therefore, in this section the results for these two singing styles will be given separately, together with some possible explanation about the reasons that kept their melodic identity separated.

The structure of *erhuang*’s O1 effectively present the so-called ‘one and a half lines’ form. When considering the schema presented in Figure

Figure 31. ***Laosheng erhuang***

31 it has to be remembered that a rather lengthy instrumental interlude is played between S2 and S3, so that S1 and S2 form a unity, with the basic motion **3 2**, **3 1**, reinforced with the expected cadence on **1**, while S3 retakes S2 basic melodic motion, **3 1**, but more articulated, and with a common caesura between S3.1 and S3.2—as explained previously, the appearance of more notes in the schema do not necessarily imply a more complex melodic surface, but a more consistent one. When the so-called 'form of connected lines' is used, O2's identity as opening line is maintained in S3.2 with the cadential movement **3 1**. Before that section, the line presents great variability, with **7̣** as central pitch. The only exception is S1, which is the only section, together with S3.1, with a consistent boundary, and where in Manban **1** can be the predominant pitch. Therefore, both pitches are present in the schema. If C shares its structure with O2, in terms of melodic motion it shares characteristics with both O1 and O2. As in O1, **2** plays an important role in the first sections of the line. Then, as in O2, **7̣** takes predominance towards the end, where the lower pitch region is emphasized. The preferred cadential motion establishes a clear contrast with both opening lines, so that the **3 1** motion is specialized in signaling the end of an opening line, while **3 2** is specialized in marking the end of the closing line, and therefore, of the whole couplet. However, and interesting characteristic of C is that, especially in Manban, it can also use a lower cadential motion in **7̣ 5̣**. This motion, that replicates an octave lower the analogue one in female singing, which is conceived as being derived from male singing, raise the question about a possible original cadential

motion in *erhuang* as **7̣ 5̣**, or if this is a later influence of female singing, which developed a cadential motion of its own because of pitch range limitations, on male singing.

		lyrics (lines)
O1	X X X X X X X X X X	
		melody (lines)
		lyrics (sections)
O2, C	X X X X X X X X X X	
		melody (sections)

Table 16. Lyrics and melody structure in *erhuang* couplets.
X stands for a character in the given line.

Besides the characteristics of its melodic identity as just described, two important elements of *erhuang*'s melodic structure should be highlighted. Firstly, the use of both an asymmetrical and a symmetrical structure for the couplet. The first one, resulting from the combination of O1 and C, is commonly used at the beginning and the end of arias, where *erhuang*'s identity is needed to be clearly marked. Perhaps due to the lengthy nature of O1, central couplets of an aria are sung with only one line structure, resulting in a symmetrical couplet formed by O2 and C. This way, the singing becomes more agile and advances with more fluidity. On the other hand, an interesting characteristic of *erhuang*'s melodic structure is its disagreement with the lyrics structure, as previously explained and summarized in Table 16. This disagreement gives *erhuang* a very unique character.

The melodic schema of *erhuang* female singing (Figure 32) shows exactly the same structure as its male singing counterpart. However, regarding its melodic identity, more interesting characteristics are found in comparison with its male version from which the state of the art literature assumes it is derived. The melodic motion in C shows the clearest similarity between male and female singing, with a common general outline in the form of **2 7̣ 3̣**, **7̣ 5̣**. However, the preference of the **3 2** motion in male singing for the cadence raise the aforementioned questions. Regarding

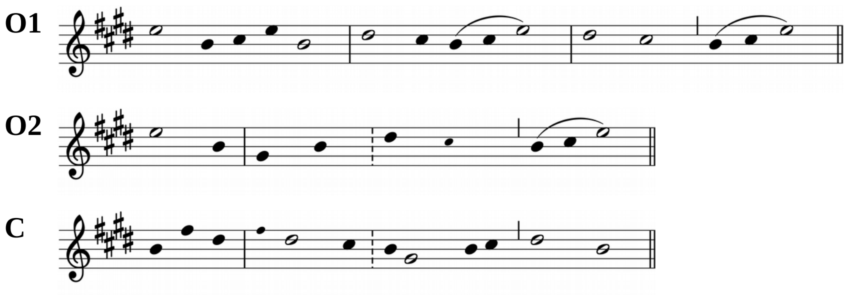

Figure 32. ***Dan erhuang***

opening lines, both male and female singing show the same cadential motive, 5̣6̣1, which unifies the opening line concluding mark in both styles. In the case of female singing O2, the importance of 7 in S3.1—which due to the blurred boundary can also be found in S2—relates to the predominance of 7̣ in its male singing counterpart. Besides, the importance of 1̇ in S1 can be related to the use of 1 in male singing Manban. However, in the case of O1, besides the already mentioned similarity in the cadential motive, the rest of the line shows very different contours. The only common point between the two is the use of 1 as S2 cadential note, which is indeed an important agreement between male and female singing, considering its one and a half lines structure, therefore marking the end of the first melodic line, before the instrumental interlude. However, most of the melodic motion in male singing occurs in the pitch region over 1, whilst in female singing occurs in the one below 1̇. As suggested in the previous section, this might be the result of the challenges resulting from shifting the pitch range a whole octave up. In the configuration of its new melodic motion, O1 might have borrowed elements from O2, as the 1̇ 5 motion in S1, or the importance of 7 in the central sections.

Consequently, even though *erhuang* female singing currently presents a distinctive melodic identity, there are also important commonalities with its male singing counterpart, especially in key structural points as cadences. Besides, the shift an octave upwards of the pitch range is a plausible cause for the deviations of the current melodic motion from an assumed derivation of female singing from the male one. Borrowings from different sources have been suggested as possible explanation for different elements of the current melodic motion. Consequently, even though male and female singing present distinctive identities in the arias that were transmitted to us, and considering that there is a lack of factual evidence to empirically certify it, the commonalities between male and female singing in *erhuang* render the possibility of the latter being derived from the former as plausible.

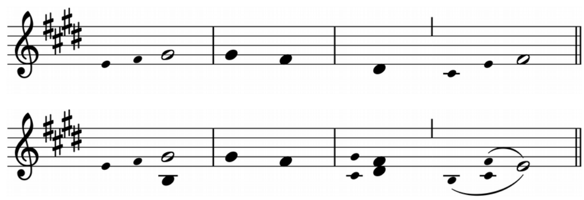

Figure 33. ***Laosheng xipi***

The melodic identity of male singing *xipi* (Figure 33) is much straightforward than *erhuang*. In this case, couplets are sung only with one symmetrical structure, which directly agrees with the lyrics structure. The main exception would be O-S3 in Yuanban, where the two subsections are comprised in a single one, as previously discussed. Regarding melodic motion, both O and C show an almost identical form except for S3.2, where each line type's identity is marked by the preferred cadential notes. Compared with *erhuang*, the fact that *xipi* also counts with Kuaiban samples contributes to the better establishment of structural pitches, since, due to the great variability of Kuaiban lines, the structural pitches there can be assumed as the ones retaining the major representativity for the *shengqiang*. Consequently, the most schematic representation of a *xipi* melodic couplet would be **3 2** (O), **3 1** (C). Interestingly, looking at *erhuang*'s cadential phrases, the couplet is characterized for the inversion of these motions, namely **3 1** (O), **3 2** (C). The melodic motion in C presents some aspects of variability, shown in the common use of **5̣** as cadential note for S1, especially in Manban and Kuaiban, and from an upper approach in S3.1 to the final cadential **1** through **2**, preferred in Yuanban.

When compared with male singing, female singing maintains the general characteristics of *xipi* melodic structure, such as the use of only one

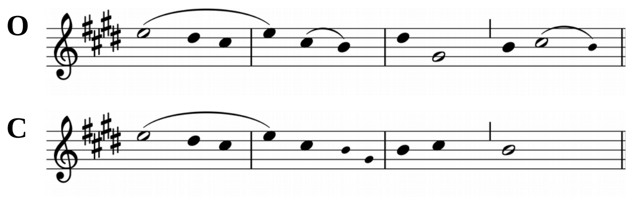

Figure 34. ***Dan xipi***

symmetrical form for setting a lyrics couplet to music, the close similarity between O and C, except for S3, and the close agreement with lyrics structure. However, the melodic motion in female singing (Figure 34) shows many differences when compared with its male counterpart. If an abstraction of the whole motion is performed as in the case of male singing, the melodic couplet could be summarized as $\dot{1}$ **6** (O), $\dot{1}$ **5** (C). From a first look, both male and female singing show similar trends. In both cases, each line starts with the same degree and progress in a descending motion, and the relationship between the cadential notes in O and C is in both cases a descending major second. These observations, especially the set of cadential notes **2**, **1** in male singing, and **6**, **5** in female singing, brought some authors to claim that male and female singing in *xipi* are related a fifth apart. However, an important difference between male and female abstracted motions should be considered. If the cadential note for C is taken as the cadential note of the whole couplet, and hence the one with a more important structural function, the initial pitch of both line types in male singing, **3**, presents a major third relationship with the cadential note, **1**, while in female singing the relationship between $\dot{1}$ and **5** is a perfect fourth. Some authors draw on this fact not to assume a transposition, but a modal shift from the *gong* mode to the *hui* mode (Section 4.4). However, female singing's melodic motion is characterized by a very distinctive descending minor second between $\dot{1}$ and **7**, forming a descending line $\dot{1}$ **7** **6**, which is consistently maintained across Yuanban and Manban lines, and which instantly identifies female *xipi*. The use of the seventh degree in other cases usually excludes the use of the first one in the same melodic phrase. Therefore, this particular minor second, consistently used in the same position, S1, presents a special strength. Consequently, this very unique melodic phrase, which is, I insist, consistently used in the same position, confers *xipi* female singing of a very distinctive identity, which finds no equivalent in *xipi* male singing. This fact might support Hai's claim that male and female singing in *xipi* stem from different *shengqiang*. The long time sharing performance space with each other, and with the rest of jingju *shengqiang*, might account for the common characteristics that male and female singing in *xipi* show nowadays, at it is the case of the commonalities between *erhuang* and *xipi*. Once more, there is a lack of factual evidence to produce a conclusive statement.

When compared with each other, there are some final general traits that can be mentioned to characterize *erhuang* and *xipi*. In male singing, *erhuang* shows a clear tendency towards lower pitch regions, being in fact **6̣** the most frequently sung degree, and the predominant pitch range can be established between **5̣** and **2** (Figure a1.5). In the case of *xipi*, the pitch space is focused on **1** and **2**, and the central pitch range is extended between **6̣** and **3** (Figure a1.6) and more concentrated than *erhuang*, which shows a flatter distribution of pitch space. An interesting characteristic of *erhuang*'s pitch space is the high use of **7̣** in comparison with *xipi*, respectively 9.38% vs. 4.2% (Tables a1.5 and a1.6), more than the double. In the case of female singing, this tendency is maintained, with 13.93% of use of **7** in *erhuang*, vs. a 7.2% in *xipi* (Tables a1.7 and a1.8). However, in female singing the most striking difference lies in the use of the first degree **1̇**, which accounts for 13.55% in *xipi*, but drops to a 10.62% in *erhuang*. Therefore, the predominance of **7̣** (or **7**) in *erhuang*, is one of the most relevant characteristics of *erhuang*, which can be explained by the importance of this degree in its O2 and C. When both role types are considered together per *shengqiang*, *erhuang* shows a very flat distribution of its pitch space (Figure a1.3), which can be explained by the importance of the lower octave in male singing and the shift an octave apart of female singing. In *xipi* though, the pitch space is concentrated in the central octave (Figure a1.4), where most of both male and female singing melodic motions occur.

Finally, considering the general data about the intervallic space, conjunct steps are predominant in both *shengqiang*, with a use of 72.15% in *erhuang* (Table a3.3), and of 69.66% in *xipi* (Table a3.4), summing up the percentages for major seconds and minor thirds. Regarding larger intervals, the use of major thirds is 0.58 points higher in *erhuang* than in *xipi*, perfect fourths are 0.39 points more frequent in *xipi* than in *erhuang* and perfect fifths are 0.4 points more frequent in *erhuang* than in *xipi* (Tables a3.3 and a3.4), just to mention those intervals which are used more than 1%. The other interval above this threshold is the minor second, which is 1.06 points more used in *xipi* than in *erhuang*. Looking closer, this interval is 1.78 points more frequently used in female *xipi* than in female *erhuang* (Tables a3.7 and a3.8), and if the direction of the interval is considered, the descending minor second is 1.35 points more used (Tables a4.7 and a4.8). This difference in such a significant interval as the minor second in a music which predominantly draws on a anhemitonic pentatonic scale, might be motivated by the distinctive $\dot{1}76$ phrase from female *xipi*. These data shows a much more nuanced vision of the claim that *xipi* makes use of larger intervals than *erhuang*. This claim, however, might arguably be the result of the scholar's personal experience, as already discussed, and consequently it might express not only the predominance of larger intervals in one *shengqiang* over the other in terms of statistical data, as here presented, but perhaps also considering other factors like the use of such intervals in relevant positions, which make them more prominent to the listener. Consequently, this claim requires further study in order to conclude a solid support, or rebuttal, from empirical observation.

Chapter 8 Conclusions

Musical creativity in Chinese traditional xiqu is based on a unique system. Jingju, as one of its more developed and refined genres, presents one of the most advanced exploitations of this system, and it is therefore one of the most representative cases for the study of the possibilities that such system offer. In order to understand musical creativity in jingju, I drew on primary literary sources, both by Chinese and English writing scholars (Section 2.1), but also, benefiting from my previous training in ethnomusicology, on direct experience with jingju actors, actresses and composers during fieldwork in NACTA (Section 3.2). As a result of this study, I was able to achieve an overall understanding of jingju musical system in particular, and its function within the synthetic nature of this art form in general, as presented in state of the art literature (Chapter 4). This system, regarding singing melody, is formed by four essential elements, namely role type, *shengqiang*, *banshi* and lyrics structure. However, of these four elements, I concluded that the description of *shengqiang*, the element that provides the underlying melodic structure for music creation in jingju, is the less complete among all the elements, and in any case, the less satisfactory for my comprehension (Section 1.1). Consequently, in this thesis I aimed at contributing to the better understanding of precisely this element, *shengqiang*. To that aim, I proposed a novel approach mainly based on computer aided musicology (Section 1.2), but informed by the just mentioned fieldwork experience at NACTA. The central method of this proposed approach is the comparative analysis of traditional jingju melodic lines, with the aim of obtaining a melodic schema of *shengqiang*'s underlying structure (Section 3.1). To support and expand the results obtained from this analysis, I benefited from the research context within with my research was carried out, namely the CompMusic project, in order to develop computational tools for the extraction of statistical and quantitative data (Section 3.3).

The proposed approach therefore establishes a data driven methodology. A review of the state of art of similar approaches to jingju music research concludes that neither a corpus with appropriate data for the implementation of the proposed research task, nor specific tools with satisfactory results for the analysis of jingju music recordings, were available. Consequently, the first step required for the implementation of the proposed methodology was the creation of a suitable research corpus, a task that was a central objective of the CompMusic project. During the research here presented, I devoted important efforts to the creation of the JMC, in collaboration with other members of the CompMusic project (Chapter 5). If this corpus was created with a broader purpose that the one this thesis aims to address, it contains the data collection that became my research object, the machine readable scores of the JMSC, which I created specifically for this task (Section 5.2). As a conclusion of the literature review, and in order to define the criteria for the creation of this collection, I focused on the two main *shengqiang* that characterise jingju music, namely *erhuang* and *xipi*. I also restricted the instances of role types to the more representative ones of the male and female singing in which jingju role types are divided, namely *laosheng* and *erhuang*. Due to technical reasons, the collection was limited to metred *banshi*. In order to establish a guide for the selection of the scores to be included in the collection, I drew on three jingju music textbooks currently used as references in NACTA. Once the machine readable scores were created, they were also annotated to the line level with information regarding the four elements of the jingju musical system, the lyrics and their linguistic tones, and the starting and ending offsets of the line and each of its three sections in the score.

Having established a research corpus, I carried out the analytical work on it. One of the external factors to the jingju musical system which presents a direct influence on the melodic surface of jingju arias are the linguistic tones of the lyrics. However, no definite agreement has been reached yet among scholars about the nature of this influence. Since I had a collection of machine readable scores with curated annotations related to linguistic tones, I performed a quantitative analysis with statistical information computationally extracted with a code written to that aim (Chapter 6). Finally, taking into account the results of this analysis, I performed the comparative analysis of the collection. To this goal, I classified the lines contained in the JMSC into 24 line categories, according to role type, *shengqiang*, *banshi* and line type. These lines were grouped in single files where they were aligned in terms of their three line sections for a better comparison. As a result of this comparative analysis, 24 melodic schemata were produced per each of the line categories. To support and expand the discussion about these melodic schemata, I wrote a code for automatically extracting statistical and quantitative information in form of plots and tables (Annex 2). With the aim of reaching a closer description to the underlying structure of each *shengqiang*, I performed a comparative analysis of the 24 melodic schemata, to produce new ones that would represent *erhuang*'s and *xipi*'s melodic identity for the basic melodic unit, that is, the couplet. Even though these schemata are still specific for male and female singing, a discussion is offered about their relationship, concluding that is closer in *erhuang* than in *xipi*.

I am confident that the results obtained in this thesis make important contributions both in terms of the addressed research problem, and of the novel methodology proposed, which shows itself promising for the study of xiqu music. However, I am also aware that the undertaken research present several limitations. These limitations open up paths for future work, in which the methods here implemented should be expanded and perfected. Finally, the understanding of *shengqiang* reached during this research invites to a comparison with other Asian melodic systems, which allows a better comprehension of the concept of *shengqiang* itself, and of musical creativity in Chinese traditional xiqu in general. In the remaining of this chapter I will address respectively these issues, namely contributions and limitations of this thesis, paths for future work it opens up, and a reflection on the concept of *shengqiang*.

8.1. Contributions and limitations

Contributions

The major expected contribution of this thesis is related to the proposed research task, namely deepening the understanding of *erhuang* and *xipi* in jingju, and consequently also the understanding of the concept of *shengqiang* itself. The proposed contribution to that goal are the **melodic schemata** presented and discussed in Chapter 7. I argue that the relevant aspects of these schemata are the ones detailed below.

- Since *shengqiang* is conceived as an underlying melodic structure, the melodic schemata offer a representation of precisely the underlying melodic motion that characterizes both *erhuang* and *xipi*. Common approaches by Chinese scholars, when explaining a *shengqiang*, usually offer an example of a real aria as illustration (Jiang$_2$ 1995, Liu$_1$ 1992, Zhang$_5$ 1992, "jingju" 1999, Cao 2010). However, as explained in detail in Chapter 4, the melodic surface that is actually performed in a real aria is influenced by many factors, of which *shengqiang* is just one of them, and precisely one that is not obvious from that melodic surface. Consequently, the melodic schemata proposed in this thesis offer a representation of the melodic identity that defines *erhuang* and *xipi*. On the other hand, compared with Whichmann's "characteristic pitch progressions" (1991: 79) or Zhang$_3$ Yunqing's "nuclear notes" (2011: 25–27), this thesis' melodic schemata not only characterize a common melodic trend, but identifies the directionality of the melodic motion that underlies couplets set to music in a given *shengqiang*, therefore accounting also for the melodic structure.

  Arguably, the closest representation of *erhuang* and *xipi* melody identity in the state of the art literature is the one proposed by Schönfelder (1972). Since the author rejects the attempt of identifying each *shengqiang*'s 'fundamental contour' [*Urgestalt*], the results of his analysis are focused on the 'units of [melodic] meaning' [*Sinneinheiten*] inferred from the analysis of his database. These units are limited to the line section, and are given separately, without integrating them into a global melodic entity per line. Besides, the author attempts for all the variations present in the analysed data, offering a series of variations per defined unit. As a consequence, Schönfelder's results consist in a list of melodic phrases that can be combined with each other to build one of the, according to the author, possible forms of each *shengqiang*'s melodic contour. In my opinion, these units are more related to the repertoire of melodic motives that form the jingju musical common (Zhang_5 1994a), or formulaic (Stock 1999) language, than to each *shengqiang*'s melodic identity. Of course, I don't assume the resulting melodic schemata presented in this thesis to be *erhuang*'s or *xipi*'s 'fundamental contour,' a terminology that, as pointed out in Section 3.1, shows a clear influence of Schenkerian analysis, the principles of whose theoretical framework were not adopted for this thesis, but the result of the comparative analysis performed on the studied data (Section 7.1). Therefore, the schemata are directly dependent on the data analysed, and reflect their commonalities. They cannot be understood in their literality, however, as a conceptual framework used by those actors who arranged the analysed melodies, a task that requires, in my opinion, a cognitive approach.

- They offer a ground from where to study the arrangement work that gave birth to a particular melodic line in the arias that are actually performed nowadays. The 24 melodic schemata, which account for *banshi* information, allows a study of the transformation process which that melodic motion experiences when adapted to a particular *banshi*. The distinction between male and female singing also provides a source for the influence of the singing division and provides a nuanced vision of the female singing as derived from the male one. The discussion of the schemata also offers explanations about the possibilities for variability, mostly based on borrowing from other line categories, supporting the formulaic character of jingju music arrangement.
- These schemata are the result of a data driven, empirical approach applied to the larger corpus of jingju music scores to date, the JMSC. Differently from the aforementioned Whichmann's "char-

acteristic pitch progressions," or, more importantly, "basic melodic contour" (1991: 80, 87) and Zhang$_3$ Yunqing's "nuclear notes," for which the authors do not offer any explanation about their origins, the melodic schemata presented in this thesis are the result of a comparative analysis of a collection of jingju music scores, whose analytical process is thoroughly documented in this thesis. Besides the analysed data, the JMSC, is available for research purposes, including the reproduction, correction or improvement of the obtained schemata. Besides, compared with other analytical approaches, such as those by Pian (1972), Schönfelder (1972) or Stock (1993, 1999), the analysis here presented is applied to the larger collection of data. The size of the analysed JMSC, in such a bottom-up approach, confers the obtained results a high degree of representativity.

Besides the melodic schemata, this thesis expects to have contributed to the understanding of the **relationship between linguistic tones and melody** by implementing, also for this topic, a data driven analysis based on statistical and quantitative information. Compared with the descriptions of this relationship that are common in the state of the art literature, which Xu$_2$ Zheng characterizes as based on the personal experience of their authors (2008), the results of the study presented in this thesis are obtained through an empirical approach, therefore providing some objectifiable data. These results, even though are far from solving this question, contribute with some interesting facts that help to define some trends and to support some hypothesis about the dialect taken as a reference for the melodic implications. Besides, the methodology seems to have been proven promising for further research on the topic. Regarding the main task of this thesis, the better understanding of jingju *shengqiang*, the obtained results in this specific task, specially those related to tone 1, were taken into account during the comparative analysis, and helped understand the alternative melodic movements in which this tone is involved, as reflected in the corresponding melodic schemata.

A third expected important contribution of the research work that led to this thesis is the creation of the **Jingju Music Corpus**. As explained in Chapter 3, the JMC is the result of a collective effort, to which I personally made an important contribution. This corpus is the largest collection of data purposefully gathered for the study of jingju music in general, and jingju singing in particular, which furthermore is openly available for research purposes. The corpus was also created with the aim of been studied from a computational approach, and also in this regard, it is accompanied by an important and well curated collection of metadata and annotations. Regarding the specifics of this thesis, the most direct contribution to the JMC is the **Jingju Music Scores Collection**, which I created myself. Besides the value of having a collection of 92 machine readable scores, containing both the melodic and instrumental lines, and the sung lyrics, another valuable aspect of the JMSC is the accompanying files with annotations related to the musical and linguistic characteristics of each of the 899 lines, which are the relevant units for the study presented in this thesis. The CompMusic project expects that the JMC will benefit both the musicological and the computational approaches to the research of jingju music, and I personally hope that the JMSC in particular can provide with useful data, metadata and annotations to researchers and scholars interested in related topics.

According to the proposed methodology based on computer aided musicology, a series of algorithms were written with the aim of extracting statistical and quantitative information from the JMSC. The resulting **code**, as well as the **plots and tables** returned by these algorithms are also an expected contribution of this thesis. Even though the code has been written for the specific needs of the research here presented, it is expected to benefit the exploitation of the JMSC for future research tasks. On the other hand, not all the plots and tables returned from the use of this code were used in the analysis presented in this thesis. However, I understand that they might contain useful information to scholars and researches interested in quantitative data about the analysed elements. Consequently, they are all added to this thesis in the hope that they will benefit future research.

To address the research question proposed in this thesis, I proposed an, according to the state of the art approaches to the topic, **novel methodology** based on computer aided musicology. This methodology stems from the hypothesis that computationally extracted statistical and quantitative information can support and expand traditional, manually implemented analyses. Consequently, the research here presented was also assumed as a proof of concept. Computational tools have been used in two tasks, namely the study of the relationship between linguistic tones and melody, and the extraction of information regarding different melodic features of the analysed melodic lines. The results obtained for both tasks, respectively presented and discussed in Chapter 6 and Chapter 7, indeed show that they contribute with valuable information for the global conclusions. In the case of linguistic tones and melody, they provided with statistical evidence for the overall melodic behavior of each tone category, but also for the necessary nuanced consideration about all of them, with perhaps the exception of tone 1, since another important conclusion of the obtained data is their high degree of variability. Regarding the second task, the plots and data also contributed with quantifiable information about general trends observed in the state of the art literature. Of special relevance is the information about intervals, since it raises questions about the common assumption of major use of large intervals in *xipi* when compared with *erhuang*.

This information not only supports and expands the results of the comparative analysis, but in occasions it contributes and leads the analytical process itself. In this sense, the pitch histograms per line sections and the charts for cadential notes showed themselves specially useful. Regarding the first ones, in many occasions they signal the preferred pitch regions and even the predominant pitches in a particular section, thus pointing to notes of possible interest. As for the charts of cadential notes, they helped, as discussed in Section 7.3, to establish section boundaries and evaluate common assumptions in the literature about preferred cadential notes. However, these data just provided some guidance, but in no case absolute conclusions that should not be confirmed by manual analysis. Some statistically predominant cadential notes were to be understood as the result of the common use of *tuoqiang*, or of cadential descending inflections, so that the cadential note is hidden by a transcription artifact. In other occasions, pitches that are statistically predominant, are not structurally relevant. Therefore, the analytical leads provided by the statistical information, if enlightening in many occasions, should always be contrasted and validated by manual analysis. As a final conclusion, I feel confident to argue that the proposed methodology is effective and valuable for the proposed task. However, the computationally obtained results always required a manual supervision and validation. This is an important reason for considering the proposed methodology not as computational musicology, but, as claimed, computer aided musicology.

Finally, I would argue that an important value of this thesis is that all the analysed data, written code and produced plots and tables are **accessible** through the companion web page. Besides, following the CompMusic project's commitment with **reproducibility**, scripts are provided so that all the plots and tables included in the thesis, including the statistics about the relationship between linguistic tones and melody, can be reproduced with only a single command line.

Limitations

Besides the expected contributions previously listed, there are some limitations of the present approach that should be considered in order to fully evaluate the produced results. If one of the advantages of the proposed methodology is the possibility for working with a large corpus of data, the limitations of this corpus constrain the representativity of the proposed melodic schemata in terms of *shengqiang* in its fullest expression. As discussed in Section 5.2, the JMSC present two important limitations. The first one is due to technical reasons, which resulted in the lack of non metred *banshi* within the collection. The second limitation is related to the temporal constrains of the undertaken research. Since all the scores that form the JMSC were manually created by myself, I had to consider some criteria for delimiting the required effort within the possibilities of the present work. Therefore, since *laosheng* and *dan* are the most representative role types for respectively male and female singing, the JMSC only includes scores for these two role types. Consequently, even considering that the analysed data contained the most representative instances of these two elements, namely *yuanban* for *banshi* and the mentioned *laosheng* and *dan* for role types, the inclusion of non metred *banshi* and other role types in the analysis might have contributed with new insights that could have influenced the resulting melodic schemata.

On the other hand, the sources for selecting the scores to be included in the JMSC where the three textbooks mentioned in Section 5.2 (Liu_1 1992, Zhang_5 1992, Cao 2010). The selection of arias presented in these three works, even though consisting in traditional repertoire, is the result of a scholar tradition with an important applied purpose, as discussed in Section 2.1, such as the training of jingju music composer. Consequently, it reflects the understanding of *shengqiang* within this scholarly tradition rather than of the concept among performers or audience. Consequently, even though a series of criteria were established for ensuring the maximal representativity of the analysed data, it has to be pointed out that the results here obtained cannot be claimed to offer a comprehensive representation of jingju *shengqiang* in its fullest expression, but of its qualities as present in a, even if representative, in any case limited selection of their instances.

The second limitation to be considered is related to the proposed methodology of computer aided musicology. Even though the computationally extracted information has proven to make important contributions to the final results, however, the potential of this approach was restricted by my limited competence in these methods. The field of MIR is addressing topics and developing technologies of relevance for the research task addressed in this thesis, such as automatic pattern discovery or automatic tune family identification. However, their implementation requires a deep knowledge of computer sciences, which I was not able to acquire during the time span of this doctoral research. In several collaborations with my fellow engineers interesting results were obtained (Caro et al. 2014, 2015, 2017a, 2017b, Dzhambazov et al. 2016, Gong et al. 2017c, Srinivasamurthy 2014a, Zhang_1 et al. 2014, 2015, 2017). However, the tasks addressed in these collaborations depended on the field of expertise of my fellow engineers.

Finally the scope of the proposed analysis imposed some limitations for the understanding of *shengqiang* in its fullest expression. Firstly, the research object was restricted to the singing component of jingju arias. However, the instrumental accompaniment, and especially the preludes and interludes of the civil section, play an essential role in setting the melodic identity of a *shengqiang* considered in its broadest sense. As mentioned in Section 3.2, even young jingju performers would rely in these elements for recognizing the corresponding *shengqiang* and *banshi*. Consequently, these instrumental lines surely contribute to the melodic identity of both *erhuang* and *xipi*. On the other hand, the analytical unit was restricted to the lyrics couplet. Indeed, this is the essential entity for which a *shengqiang* provides melodic material. However, the sequence of couplets in an aria do not merely repeat this melodic material once and again. Generally, non musical factors such as the content of the lyrics or the dramatic context are adduced to explain melodic variability across couplets. However, Stock analysed how in two couplets arias sung by Zhou Xinfang, this *laosheng* actor arranged their music having the four lines structure in mind (1999). The mere fact that *erhuang* uses two forms of opening line is a clear testimony to a musical quality of *erhuang* beyond the couplet, which is clearly different in *xipi*. Consequently, the results obtained in this thesis should be also complemented with analysis of the instrumental line and larger than a couplet structures in order to obtain a comprehensive understanding of the musical characteristics of jingju *shengqiang*.

8.2. Paths for future work

The contributions that are expected to have been achieved during this thesis seem to support the conclusion that the proposed methodology is able to achieve satisfactory results for the study of jingju *shengqiang*. This opens up interesting paths for future research, some of which will be pointed out in this section.

The satisfactory results obtained in the research here presented were dependent on the quality of the collection of data upon which the analysis was applied, and their corresponding annotations that enabled its computational exploitation. Consequently, this outcomes testify that the effort invested in corpus creation are rewarding and productive. As explained in Chapter 5, in the CompMusic project research corpora are understood as ever growing entities which might add new data as long as they satisfy the general criteria according to which the corpora were created. Consequently, the creation of a research corpus is conceived as an always ongoing task, to which is important to devote continuous efforts. In the future, the JMC can be improved with the addition of new data and more precise annotations, as well as creating well defined and curated, task specific test datasets. Specifically considering the data analysed for this thesis, the JMSC, future efforts should be invested in overcoming the limitations stated in the previous section, not only by adding scores related to the missing entities, such as non metred *banshi* and other role types, but also by diversifying the selection sources so that the widest representation of jingju music possible can be obtained. One of the important challenges that this expansion of the JMSC poses consists in finding a satisfactory system for the machine readable notation of non metred segments, as well as techniques for its computational processing. Most of the current protocols, such as the currently used MusicXML, and music score processing systems, as the one used for this thesis, music21, are designed for the management and analysis of scores written in European staff notation. However, there is an increasing consciousness for addressing other notation traditions, to which the CompMusic project has made important contributions and is expected to continue contributing in the future with subsequent related projects.

In Chapter 5, I described the potential of each of the collections in the JMC. Exploiting this potential offers interesting opportunities for future research. In order to do that, it has to be considered that the JMC was created for its study from computational approaches, and therefore it is through these methods that the maximum benefit can be obtained. In that chapter I pointed out possible research tasks to profit from each of the JMC's collection, but I would like to highlight here some of them of special interest for the task undertaken in this thesis, namely the study of jingju *shengqiang* in particular, and of jingju singing in general. To this goal, I argue that the two most relevant collections are the JMSC and the JaCRC. The potential of the former has been partially exploited for this thesis, even though, as discussed in the previous section, the use of computational tools was limited. The formulaic character of jingju music arrangement has been discussed throughout this thesis, and new hints towards the understanding of this phenomenon were provided in the analysis of the melodic schemata (Sections 7.3 and 7.4). Automatic pattern discovery is a currently very active research task in the MIR community that could contribute to the study of this phenomenon. A preliminary application of these techniques on the JMSC was attempted, but many technical and conceptual difficulties were found in the process, which let us postpone this research direction. Among them, the most important one was the lack of a ground truth against which to evaluate the obtained results. Automatic tune family classification is another potentially relevant technique for the study of jingju musical dimension. Applying techniques usually developed to be applied in biological studies, this approach aims at creating genealogical trees of the given dataset by measuring similarity between data units. The application of such techniques to jingju singing lines might provide with interesting insights about melodic consistency and variability, as well as personal and school styles, borrowing across categories, etc. Finally, computational approaches to the study of similarity can be applied to the study of the relationship between the sung melody and the accompaniment melodic line, in order to characterize jingju heterophonic texture.

All these tasks can be also applied to the JaCRC, which might be the most novel contribution of the JMC. The fact that singing is recorded without accompaniment allows for a satisfactory extraction of the pitch track, which can be used for the just mentioned research tasks. Since the collection includes tracks for solo jinghu accompaniment, the study of this line can become also a research object on its own, or in relationship with the singing melody. Working with audio allows studies of more subtle dimensions, as the ones attempted in Caro et al. (2015), concerning performative aspects of style, such as vibrato, loudness, timbre, etc. The annotations to the syllable level accompanying some datasets of the collection can be used for more fine grained studies on melodic articulation, and for the characterization of personal or school styles.

All the aforementioned techniques, as pointed out in the previous sections, require a proficient knowledge of MIR and other disciplines in the range of computer sciences. On the other hand, the input of musicologists is unavoidable in order to define a meaningful research question and an appropriate methodology, as well as to provide required annotations to be used as ground truth and collaborate in the design of relevant evaluation methods. Consequently, future paths for the computational exploitation of the JMC will produce a maximum profit if it is done by research teams of collaborators from at least jingju musicology and MIR, as the experience in the CompMusic project has proven.

All the approaches mentioned so far lie within the scope of the two main disciplines that converge in the CompMusic project, namely musicology and MIR. However, the JMC opens up possibilities for research projects from other disciplines. Recently, NLP methods were applied to the JLC in order to study the relationship between the jingju lyrics content and their setting to a specific *banshi* (Zhang_1 et al. 2017). This collection enables the study of jingju lyrics from a computational linguistic approach, not without important challenges, since, as described in Section 4.2, jingju uses a special linguistic construct for whose computational processing specific approaches should be developed. Black et al. (2014) developed the SVAD for the research of emotional cues in jingju. This research sets a precedent for the study of jingju music from the discipline of music cognition. Perception of melodic similarity will shed relevant insights on the melodic identity of *shengqiang* and *banshi*, and also on the relationship between linguistic tones and melody. Finally, the data available in the JMC, the corresponding annotations, and the developed technologies offer a very useful material for music education and the training of jingju listenership, both among Chinese and international audiences.

Finally, considering that the results presented in this thesis prove the proposed approach fruitful for the addressed task, this methodology can be applied to future research on the topic of this thesis, the musical dimension of Chinese traditional theatre, by progressively expanding its analytical scope. I envision this expansion in three steps. Firstly, as already described in the previous section, the study of *erhuang* and *xipi* here presented is limited in terms of *banshi* and role types, as well as of the exclusive focus on sung melody. Therefore, the natural continuation of the current task is to expand the analytical scope to the fullest manifestation of these two *shengqiang*. If in this first approach to the topic only the two main *shengqiang* of jingju were considered, in a further step the whole set of jingju *shengqiang* should be studied. The goals of such research task would be, firstly, to establish the melodic identity of each of the multiple *shengqiang* used in jingju, but also to study the mutual influence across them in order to identify melodic features that can characterize jingju's own melodic identity. Finally, the broadest scope would consider the *pihuang* system. The goal of this approach is to identify common melodic features for both *erhuang* and *xipi* across xiqu genres that belong to this system. The results of such an ambitious research task would inform, on the one hand, about the melodic identity of these two *shengqiang* in its broadest sense, and more interestingly, on the other hand, they would contribute to the understanding of *shengqiang*—and also of the concept of *shengqiang* system—as a principle for melodic creativity in Chinese traditional xiqu, accounting for their historical and regional implications. If the goal is to benefit from, and improve the methodological approach proposed for this thesis, the preliminary step for these future paths would be the creation of corresponding research corpora, a formidable research task in itself, but which, if made openly accessible, can make an also formidable contribution to the research community.

8.3. *Shengqiang* among world musics

In the CompMusic project, the availability of research corpora from five different music traditions stirred the interest for cross-cultural studies, which however have not yet been properly addressed. This interest was present from the inception of the project, and in fact contributed to the criteria for the creation of these corpora, which have the voice as the main focus, and for the delimitation of the main research domains, which are the melodic and rhythmic dimensions of these traditions. In order to engage in such cross-cultural study, comparable elements from the musical system of each tradition were needed to be identify as accounting for their melodic and rhythmic dimensions. This thesis has *shengqiang* as its central object of study, which is precisely the main element of the jingju musical system that is concerned with melodic creation. From the remaining music traditions, the elements that play a similar role in determining their melodic aspects are *rāga*—a compromise term to represent the common aspects of both Hindustani *rāg* and Carnatic *ragam*—*makam* from Ottoman-Turkish classical music, and *ṭab‘* for Arab-Andalusian music. Even though the comparison of such complex music systems requires an in depth extensive study, I would like to conclude this thesis by looking at *shengqiang* as an entity, and contribute to its understanding through some preliminary reflections spurred by the stimulating intellectual environment of the CompMusic project.

My colleagues working on melody in Indian art music had at their disposal abundant literature about *rāga*, but still found it problematic to define the term, a testimony of the elusiveness of this concept to be grasped with English terminology, designed for describing very different musical realities. Arguably, one of the most complete definitions of *rāga* is the one offered by Bor in *The Raga Guide* (1999), which states that

> a raga can be regarded as a tonal framework for composition and improvisation; a dynamic musical entity with a unique form, embodying a unique musical idea. As well as the fixed scale, there are features particular to each raga such as the order and hierarchy of its tones, their manner of intonation and ornamentation, their relative strength and duration, and specific approach. Where ragas have identical scales, they are differentiated by virtue of these musical characteristics. (1)

In this definition, Bor puts the focus on its value as a source for music creation by providing a series of musical elements of which the central one is a scale. Throughout the book, when each of the 74 selected *rāgas* are presented, the authors offer three important elements, namely an ascending and descending scale, a melodic outline, and brief text accounting for specific melodic features of each particular *rāga*. Among these features, an essential one is the definition of which degrees of the scale have a predominant function, therefore establishing the hierarchy of the scale. At least three predominant degrees are considered. The most important one is the *ṣaḍja*, or *sa*, which is always the first degree of the scale. Then, different *rāgas* select two degrees as *vādī* and *saṃvādī*, which, after the *sa*, are the most predominant degrees in the scale. Consequently, scale, its direction, the hierarchy of its degrees and preferred melodic movements as illustrated by a corresponding melodic outline, are the central elements—although not all of them—that define a *rāga*. The particular combination of specific instances of these elements to form a concrete *rāga* confers it the capability of expressing, in Bor's words, "a unique musical idea," or in Daniélou's words, an "emotion," a "mood" (2010: 91).

The case of Ottoman-Turkish classical *makam* is quite similar in terms of the elusiveness of its definition. In publications such as *Makam* by Signell (2008) or *Turkish music makam guide* by Aydemir (2010), both authors focus on similar aspects when describing both the concept of *makam* and specific instances of it. As in the case of *rāga*, the scale is a central element, and the two tetrachords or pentachords that form it. As in the case of *rāga*, hierarchy of degrees and melodic directionality are important elements defining a specific *makam*. The most important degree of the scale is the first one, the *durak*,[1] followed in importance, according to Aydemir, by the *güçlü* and the *yeden*, which both Aydemir and Signell translate respectively as dominant and leading tones. *Seyir*, or the overall progression of the melody, is another defining trait of a particular *makam*. Finally, a rather elusive, but essential concept that characterises *makam* music is the one of *çeşni*, literally meaning 'taste, flavor, spice' (Aydemir 2010: 19). Davis argues that this is an ambiguous concept since "while some seem to apply it in the sense of a modulation as a change in the structure of the scale, others apply it to melodic phrases that use notes that are considered part of the makam" (Powers et al. 2001). In any case, it seems that *çeşni* relates to some aspect of the melodic outline and its evolution through performance. And it is this element, the literally "taste, flavor," the one analogue to the *rāga* function of conveying a musical idea, an emotion, a mood.

According to the musician and musicologist Amin Chaachoo, the origins of Arab-Andalusian music should be found in the local traditions of medieval Spain where it was formed, even though with important contributions from the Arab ones, specially regarding the language and poetic forms (2016). Consequently, the author draws on medieval Spanish music theory, especially the one related to Gregorian chant, for the development of his theory of Arab-Andalusian music in its Moroccan tradition known as *al-Āla*. In his description of each of the 26 *ṭubūʿ* (plural form of *ṭabʿ*) performed in the *al-Āla* tradition, Chaachoo offers an ascending and descending scale, a hierarchy of degrees, consisting in a fundamental degree, which is always the first one, two or three predominant degrees, and one or two sustained degrees (similar in concept to the Gregorian reciting tone), and finally a series of characteristic melodic phrases, which the author calls *centones*, a term borrowed from plainchant theory. As in the case of *rāga* or *makam*, *ṭubūʿ* also have associated expressive functions. Indeed, Chaachoo talks of the "emotional characteristics" and the "spiritual characteristics" of a *ṭabʿ* (2016: 134).

The comparison of these three concepts, *rāga*, *makam*, and *ṭabʿ*, show that all of them share several essential characteristics. All of them have a

[1] A common term for referring to this degree is *karar*. However, according to Aydemir, this concept is slightly different to *durak*, and closer in its meaning to cadence (2010: 26), being naturally the most relevant cadence for a *makam* the one on the *durak*.

scale as central element, from which a hierarchy of degrees is defined, taking always the first degree as the most important one, melodic directionality is a relevant factor in all of them, although with different manifestations, and certain pre-established melodic trends contribute to the definition of specific instances. Perhaps because of these common elements, all of them also share the usual definition as modes. Chaachoo defines *ṭab‘* as the "Andalusian musical mode" (2016: 134), the subtitle of the aforementioned Signell's work is *Modal Practice in Turkish Art Music* (2010), and one of the first studies by an European scholar about Indian traditional music was indeed entitled by his author Sir William Jones *On the Musical Modes of the Hindus*, published in 1792. Not surprisingly, the acclaimed *The New Grove Dictionary of Music and Musicians* discuss the concepts of *rāga* and *makam* only under the entry for "Mode" (Powers et al. 2001). In this entry, the term mode is presented as a continuum between two poles, namely "particularized scale" and "generalized tune." For the description of each of these poles, Powers give five defining characteristics.

1. Modes closer to the scale pole tend to provide general descriptions, while those closer to the tune pole are concerned with more specific elements.
2. The scale pole is related to theory, whilst the tune pole is focused on practice.
3. Modes on the scale pole are understood as classes, whilst those on the tune pole are conceived as functions.
4. Consequently, a mode on the scale pole is used for classification of melodies, but in the tune pole is use as a source for creation.
5. Finally, the number of modes on the scale pole is closed and reduced, while on the tune pole is large and open-ended.

In his analysis of mode in the Middle East and Asia, Powers places *rāga* and *makam* close to the tune pole.[2] Interestingly, the examples of 'modes' for the scale pole are geographically closer to jingju, namely the Indonesian *pathet* and the Chinese *diao*, also in its Japanese and Korean versions *chō* (or *jō*) and *jo*. In both cases, these modes are understood as a particu-

[2] According to the five criteria offered by Powers, I consider *ṭab‘* closer to the scale pole.

lar arrangement of the degrees of a given scale, mainly by considering in each specific mode a different finalis.

Consequently, if *shengqiang* has been assumed as the analogue principle in jingju for *rāga*, *makam*, and *ṭab'*, where will it lie within this scale-tune modal continuum, in the light of what has been learned about *shengqiang* as a result of the research presented in this thesis? Considering Power's five criteria, it seems that *shengqiang* will be closer to the tune pole. The criterion that is most clearly followed by *shengqiang* would be the fourth one, since this element is essentially a source for creation, not a standard for classifying melodies. Consequently, as it has been described throughout this thesis, jingju performers have a practical knowledge of *shengqiang*, and in many occasions are not able—and also do not need—to make an explicit theoretical definition of it. The melodic schemata here presented show that the melodic identity of a *shengqiang* provides a structural melodic motion, rather than general melodic features. The selection of a specific *shengqiang* has an expressive function, and it is the need for conveying the associated emotional atmosphere what determines the use of one or other *shengqiang*. Finally, if one single xiqu genre is considered, the number of concerned *shengqiang* is reduced and generally fixed, with many genres, such as kunju, using just but one *shengqiang*. However, considering xiqu as a general art form, the number of *shengqiang* is then very high, and without a definite count.[3]

From the previous description it is ostensible that *shengqiang* share important characteristics with *rāga*, *makam*, and *ṭab'*, of which I would like to highlight the following two: all these four concepts are sources for melodic creation, and the selection of a particular instance of any of them is motivated by the need of conveying an expressive function associated to it. However, *shengqiang* also present notable differences with these three concepts. Arguably the most notable one is that *rāga*, *makam*, and *ṭab'* are scale-centred. The definition of each of an instance of any of

[3] I have not found in the reviewed literature a count of existing *shengqiang*. Even though the concept of xiqu genre, *juzhong*, is not equivalent to *shengqiang*, it has been discussed in this thesis how some authors confer to the both of them similar content, specially in the first stages of xiqu history. There is a common estimation of more than 300 xiqu genres during the 50s (Jiang$_2$ 1995: 33, Huang et al. 2006: 245). Even though this number cannot be taken as an equivalent of existing *shengqiang*, it suggests that the instances of this element among xiqu genres might be really numerous.

these elements starts by establishing a scale. And from this scale a pitch hierarchy is also defined, in which at all times the most important degree is the first one. In case of xiqu *shengqiang*, the scale is not a relevant factor, since a predominantly anhemitonic pentatonic scale is commonly shared not only across xiqu genres, but across genres of Chinese traditional music in general. Naturally, ostensible differences in the use of this pitch material is found across genres, specially in the definition of the finalis, thus determining a specific *diao*, that is, a specific mode.[4] Consequently, as discussed in Section 4.4, the use of a particular mode is one of the characteristics that define a *shengqiang*. Being this so, can *shengqiang* be considered itself a mode—like, for example, Wichmann seems to do—when it includes within its defining elements one, or several, modes?

As presented in Section 4.4, many English writing scholars define *shengqiang* as tune families (Yung 1989, Stock 2003, 2006, Guy 2005). The concept of tune family, developed from mid 19th century within folklore studies (Cowdery 1984: 495), refers to a group of tunes which share similar characteristics. For his research on North American folk songs with origins in the British islands, Bayard sets the principles for the study of "variant forms of different individual folk tunes," so that they can be classified into tune families (1950). As a result of his theoretical discussion, the author defines a tune family as

> a group of melodies showing basic interrelation by means of constant melodic correspondence, and presumably owing their mutual likeness to descent from a single air that has assumed multiple forms through processes of variation, imitation, and assimilation. (1950: 33)

As Nettl argues, the research of tune families concerns two main tasks, namely establishing degrees of similarity between tunes, and classify them into families according to this similarity measurements (2005: 113–130). If this is the task, the conceptual implication, as Bayard states, and Nettl illustrates with the examples he provides for the discussion of this topic, is, in Cowdery's word, "a hypothetical diachronic sequence" (1984: 496).

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[4] In the case of xiqu, perhaps the most special case in the use of pitch material is found in genres originated in the north of the Shaanxi province, of which the most representative one is qinqiang, in which two scale configurations are predefined with the goal of expressing happy or sad feelings, and therefore respectively named 欢音 *huan yin*, 'happy tones,' and 苦音 *kuyin*, 'bitter tones' (Huang et al. 2006: 270, Yuan 2000: 243).

That is, the tunes contained in a family are assumed to be the result of a historical process of diversification from a common origin.

Considering the aforementioned implications of tune family as an analytical paradigm, I find the description of *shengqiang* as tune families problematic. Indeed, as the analysis presented in this thesis shows, couplets set to music in the same *shengqiang* share an important degree of similarity. However, explaining this similarity by the fact that these melodies belong to a tune family, it would carry the implication that this is the result of a historical process of differentiation. However, without denying the necessary influence of historical evolution, the differentiation of melodies which belong to one *shengqiang* is the result of a creative exploitation of its principles by jingju artists. What underlies the differences between melodies of the same *shengqiang* is not a diachronic process, but a synchronic one. The differences between the melodic schemata which are specific for a *banshi* group (Figures 7 to 30) and those which are general for a *shengqiang* (Figures 31 to 34) are not the result of a historical evolution, but of the creative transformations applied by a jingju artist in order to satisfy certain expressive needs. In fact, an aria which is formed by several *banshi* of the same *shengqiang* (as in Figure 1) present co-occurrent transformations of the underlying melodic motion that identifies that particular *shengqiang*. The process of transformation of one tune into a tune family is influenced by external, passive factors, while *shengqiang*'s melodic transformations are the result of its internal principles, put actively into practice by jingju music creators. Consequently, according to my understanding, defining *shengqiang* as a tune family conceals its most essential characteristic, which is its active source for music creation, as well as its dynamic interaction with other elements such as role type and *banshi*.

In his study of melodic creation and conceptualization in Javanese *karawitan*, Perlman addresses the common description of this music by ethnomusicologists as heterophonic. The author argues that heterophony

> is a murky term, introduced a century ago by Western scholars to stand for a generic musical Other. It was defined by the gap it filled, being whatever was neither monophony nor polyphony. [...] [H]eterophony remains a concept defined largely by what it is not." (2004: 62)

When reflecting about the definition of the concepts addressed in this section, the resources they offer to musicians for creation, and their unique principles, but also common strategies, this claim by Perlman came to my mind. Perhaps trying to fit all these concepts into a single one, which needs to be so extended in its meaning that loses descriptive capacity, is also a way of defining “a generic musical Other.” From the previous discussion, it does not seem unreasonable to argue that the meaning of the term mode, when not used as “an indigenous term in Western music theory” (Powers et al. 2001), simply is ‘non tonal music.’ Consequently, terms like *rāga*, *makam*, *ṭab‘*, and also *shengqiang* deserve not to be described with a negational term such as mode, which might only provide the reader with the information that is not tonal music. I would argue that in order to value their uniqueness as force for music creation and the cultural implications they carry in terms of the conceptualization of music as a phenomenon, these terms should be self-defined, so that from foreign terminologies they can just but be described.

With this concluding reflections, my intention has been to put in value *shengqiang* as such original force for music creation. I argue that it is a precious contribution of jingju artists to the very rich variety of human constructs to conceive music and channel music creation. *Shengqiang*, together with *banshi*, is not only used in xiqu music, but also in other sung genres such as storytelling. These two concepts, and especially *qupai*, which affects both vocal and instrumental Chinese traditional music, can be argued to be some of the more genuine musical entities developed by Chinese musicians. They carry a unique understanding of music creation as recreation, which is already found in classical poetry, with the composition of new lyrics to preexisting poetic—and in China necessarily also musical—structures. Understanding *shengqiang* is consequently a pathway to this immense realm of music thinking that Chinese musicians contributed to humankind. I hope this thesis made some contribution to this immense enterprise.

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Annex 1: Glossary

ban	板
bangziqiang	梆子腔
bangu	板鼓
banqiang bianhua ti	板腔变化体
ban qi ban lao	板起板落
banshi	板式
Bawang bie ji	《霸王别姬》
Beijing daxue bai zhou...	北京大学百周
...nian jinian jiangtang	年纪念讲堂
Beijing jing kun...	北京京昆
...Liyuan shudian	李元书店
Beijing yin	北京音
biangong	变宫
bianhua xingshi	变化形式
bianqu	编曲
bianzhi	变徵
bongji	梆子
bongwong	梆王
cai pai	彩排
chang	唱
Chang'an da xiyuan	长安大戏院
changduan	唱段
chang duan ju	长短句
changmian	场面
chang-nian-zuo-da	唱念做打
changqiang	唱腔
chang shangju	长上句
chaqu	插曲
chatjiching	七字清
Chen Kaige	陈凯歌
Chen Rui	陈睿
Cheng Dieyi	程蝶衣
Cheng Yanqiu	程砚秋
chengshi	程式
chengshixing	程式性
chenzi	衬字
chou	丑
chuanju	川剧
chuanqi	传奇
chuantong xi	传统戏
chuiqiang	吹腔
da	打
daluo	大锣
dan	旦
danpigu	单皮鼓
danqiang	旦腔
daoban	导板
daobantou	导板头
daozi	倒字
daqu	大曲
daruan	大阮
di chu	低出
di chu	低处
dianju	滇剧
diaoshi	调式
difang xi	地方戏
dizi	笛子

dou	逗
duibi	对比
duichang	对唱
dui'ou	对偶
duoban	垛板
duo shengqiang juzhong	多声腔剧种
duotou	夺头
duozi	垛字
erhu	二胡
erhuang	二黄, 二簧
erliu	二六
erliu	二流
errenzhuan	二人转
Fan Qingtao	范庆涛
fandiao	反调
fan'erhuang	反二黄, 反二簧
fansipingdiao	反四平调
fanxipi	反西皮
fushu	附属
fuzhu	辅助
gaishuo	概说
ganju	赣剧
gaobozi	高拨子
gaoqiang	高腔
gong	宫
gongting yinyue	宫廷音乐
gontong xuanlü xing	共同旋律型
gugan yin	骨干音
Guifei zui jiu	《贵妃醉酒》
guiju	桂剧
gunban	滚板
guocui	国粹
Guojia jingju yuan	国家京剧院
guojia yiji zuoqu	国家一级作曲
guomen	过门
gutaozi	鼓套子
haidi	海笛
haiyanqiang	海盐腔
hangdang	行当
handiao	汉调
Hanyu Pinyin	汉语拼音
hanju	汉剧
Hebei bangzi	河北梆子
Henan bangzi	河南梆子
hexin yin	核心音
huadan	花旦
huaguxi	花鼓戏
huaiju	淮剧
hualian	花脸
Huang Yunzhen	黄允箴
Huanggang	黄冈
huangmeixi	黄梅戏
Huangpi	黄陂
huanweishi	换尾式
huan yin	欢音
huguangyin	湖广音
huiban	徽班
huidiao	徽调
huiju	徽剧
huilong	回龙
huju	沪剧
huopo	活泼
huqin	胡琴
jia hua	加花
jiangnan sizhu	江南丝竹
Jiang Songsong	江松松
Jiangsu sheng kunju yuan	江苏省昆剧院
jianpu	简谱
jian tuan zi	尖团字
jiaoban	叫板
jiben	基本
jiben gong	基本功
jiepai	节拍
jieshu ju	结束句
jijin	级进
jin da man chang	紧打慢唱
jin shangju	紧上句
jing	净
jing'erhu	京二胡
jinghu	京胡
jingju	京剧
Jingju zhi xing	《京剧之星》
jingqiang	京腔
jinju	晋剧
jinsuo	紧缩

jinsuo ju	紧缩句
juben	剧本
jumu	剧目
jumu ke	剧目课
juzhong	剧种
Kangxi	康熙
kou chuan xin shou	口传心授
kuaiban	快板
kuaisanyan	快三眼
kunju	昆剧
kunqiang	昆腔
kunqu	昆曲
kunshanqiang	昆山腔
kutou	哭头
ku yin	苦音
langsong	朗诵
lao	老
lao si da shengqiang	老四大声腔
laoban ju	落板句
laodan	老旦
laosheng	老生
laoshi	老师
laoyin	落音
Li Shengzao	李盛藻
Li Yuru	李玉茹
Li Zhengping	李正平
lian	联
lian ju xingshi	联句形式
liushui	流水
luantan	乱弹
luogu jing	锣鼓经
Ma Lianliang	马连良
man changchui	慢长锤
manban	慢板
mansanyan	慢三眼
Medeli *jianpu* software	美得理简谱软件
Mei Lanfang	梅兰芳
Mei Lanfang *da juyuan*	梅兰芳大剧院
Ming dai si da shengqiang	明代四大声腔
minjian yinyue	民间音乐
mochang	模唱
mohu gainian	模糊概念
muqu	母曲
Mu Yi	木易
nanbangzi	南梆子
nanluo	南锣
naobo	铙钹
nian	念
paisheng	派生
pianyin	偏音
pihuang	皮黄
pihuangqiang	皮黄腔
ping	平
pingju	评剧
pingwen	平稳
pingxing	平行
Puzhou bangzi	蒲州梆子
Qi Rushan	齐如山
qiang	腔
qiangdiao	腔调
qiangge	腔格
qiangxi	腔系
qiju	祁剧
qingjue	清角
qingyi	青衣
qinqiang	秦腔
qinshi	琴师
qu	曲
qu	去
qudiao	曲调
qupai	曲牌
qupai lianzhui ti	曲牌联缀体
ru	入
ruan	阮
runqiang	润腔
san	散
sanban	散板
sanban lei	散板类
sanxian	三弦
sanyan	三眼
saotou	扫头
secai yin	色彩音
shanchui	闪锤
shang	商
shang	上

shangban lei	上板类
shan'ge	山歌
Shanghai yinyue xueyuan	上海音乐学院
shangkou zi	上口字
shangju	上句
shang xia ju	上下句
Shen Pengfei	沈鹏飞
sheng	生
sheng	笙
sheng	声
sheng dan fenqiang	生旦分腔
shengmu	声母
shengqiang	声腔
shengqiang	生腔
shengqiang xitong	声腔系统
shengyin	声音
shi	式
shuāng	霜
shuǎng	爽
si da huiban	四大徽班
si da shengqiang	四大声腔
Si lang tan mu	《四郎探母》
sigu	司鼓
sin	線
sipingdiao	四平调
Song Tingting	宋婷婷
suona	唢呐
suona erhuang	唢呐二黄
tanggu	堂鼓
tuoqiang	拖腔
Tan Xinpei	谭鑫培
taoqu	套曲
taoshu	套数
tiaojin	跳进
tiaoyue	跳跃
Tiejing gongzhu	铁镜公主
Wang Guowei	王国维
Wang Yaohua	王耀华
Wang Yaoqing	王瑶卿
wawa	娃娃
Wei sheng	《尾声》
wen	文
wenchang	文场
wenren yinyue	文人音乐
wu ban wu yan	无板无眼
wu	武
wuchang	武场
wuju	婺剧
wusheng	武生
Wu Zuguang	吴祖光
xi	戏
xiaju	下句
xiandai xi	现代戏
xiangju	湘剧
Xiangyang qiang	襄阳腔
xianzi	弦子
xiao	小
xiao dianzi	小垫子
xiao douzi	小豆子
xiaojie	小节
xiaoluo	小锣
xiaoluo *duotou*	小锣夺头
xiaosheng	小生
xieyi	写意
xin bian lishi ju	新编历史剧
xingxian	行弦
xin wenhua yundong	新文化运动
Xiong Luxia	熊露霞
xipi	西皮
xiqu	戏曲
xuanlü jinxing	旋律进行
Xun Huisheng	荀慧生
xüni biaoyan	虚拟表演
xünixing	虚拟性
yaoban	摇板
yan	眼
Yang Baosen	杨宝森
Yang *guifei*	杨贵妃
yangping	阳平
Yang Yanhui	杨延辉
yan qi ban lao	眼起板落
yanshenxing	延伸型
yanyuan	演员
yi ban san yan	一板三眼
yi ban yi yan	一板一眼
Yihuang	宜黄

yin	音
yinjie	音节
yinping	阴平
yinyue	音乐
yi qiang duo yong	一腔多用
yiwong	二王
yiyangqiang	弋阳腔
yi zhuo liang yi	一桌两椅
you ban wu yan	有板无眼
Yu Shuyan	余叔岩
yuanban	原板
yue	乐
yueju	越剧
yueju	粤剧
Yuen Ren Chao	赵元任
yueqin	月琴
yuju	豫剧
yunmu	韵母
yuqi	语气
yushi	语势
yuyaoqiang	余姚腔
yuyi	语意
za qiang xiao diao	杂腔小调
zadiao	杂调
zaju	杂剧
zan zhuandiao	暂转调
ze	仄
Zhang Geng	张庚
Zhang Junqiu	张君秋
Zhang Xuan	张玄
zhe	辙
zhengdan	正旦
zhengdiao	正调
zhi	徵
zhong deng zhiye xuexiao	中等职业学校
Zhongguo chuantong	中国传统
…yinyue gailun	音乐概论
Zhongguo jingju xikao	中国京剧戏考
Zhongguo xiqu yanjiuyuan	中国戏曲研究院
Zhongguo xiqu xueyuan	中国戏曲学院
Zhongguo xiqu xueyuan…	中国戏曲学院
…*fushu zhong deng…*	附属中等
…*xiqu xuexiao*	戏曲学校
zhongruan	中阮
zhongsanyan	中三眼
Zhongyang minzu daxue	中央民族大学
Zhongyang yinyue xueyuan	中央音乐学院
Zhongzhou yun	中州韵
Zhou Deqing	周德清
Zhou Xinfang	周信芳
zhuan ju	转句
Zhuang Xuan	庄璇
zhuti	主体
zhutou	住头
zhuyao	主要
zi	字
zidiao	字调
zi zheng qiang yuan	字正腔圆
zonghexing	综合性
zongjiao yinyue	宗教音乐
zuo	做
zuoqu	作曲

Annex 2: Plots and data

This Annex contains all the plots and data obtained by the use of the code described in Section 7.2. Each plot is followed by a related table containing the numerical values of the information displayed in the plot. These values are averaged in a scale from 0 to 1. The histograms present a color code to visually identify the analysed role type: blue for *laosheng*, orange for *dan*, and gray if both role types are analysed. In the same fashion, the hatch of the bars identify the *shengqiang*: `/` for *erhuang*, `\` for *xipi*, and `X` if the two of them are analysed together.

The plots and data are grouped in the following seven categories, identified by number preceded by 'a.'

All the plots, the data (collected in single `csv` files per group), and the code used for producing them are available in the thesis' companion web page.[1]

[1] http://compmusic.upf.edu/caro2018thesis

To simplify the name of each figure and table, the instance of each of the jingju music system element that form the category analysed for their computation, are given in an abbreviated form, as explained below:

- Role type
    - ***ls*** *laosheng*
    - ***da*** *dan*
- *Shengqiang*
    - ***eh*** *erhuang*
    - ***xp*** *xipi*
- *Banshi* group
    - **Yb** Yuanban
    - **Mb** Manban
    - **Kb** Kuaiban
- Line type
    - **O** opening line
    - **O1** opening line 1
    - **O2** opening line 2
    - **C** closing line

a1. Pitch histograms per line

Figure a.1.1. *Ls*

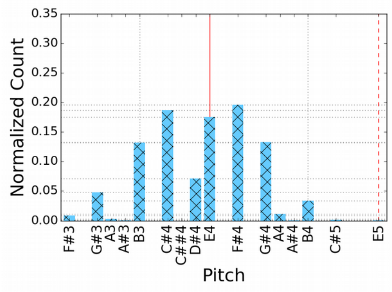

Figure a.1.2. *Da*

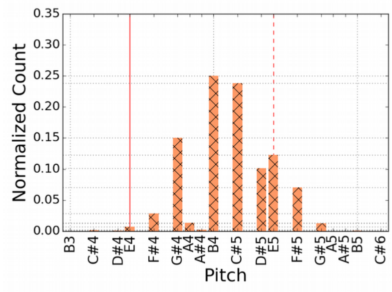

Table a1.1. *Ls*

F#3	0.00909371741901
G#3	0.0475344634514
A3	0.00274163030467
A#3	0.000386145113334
B3	0.131636869135
C#4	0.186578883011
C##4	0.00007.72290226667
D#4	0.0714046672073
E4	0.175091065889
F#4	0.195975080769
G#4	0.132428466618
A4	0.0112754373093
A#4	0.000231687068
B4	0.0339807699734
C#5	0.00137081515233
E5	0.000193072556667

Table a1.2. *Da*

B3	0.000037785397833
C#4	0.00170034290249
D#4	0.000491210171829
E4	0.00739649162581
F#4	0.028735795052
G#4	0.150278824748
A4	0.0131209793975
A#4	0.00251272895589
B4	0.250473104669
C#5	0.2380196673
D#5	0.100943690311
E5	0.12293479185
F#5	0.070479213308
G#5	0.0121668981022
A5	0.000151141591332
A#5	0.0000188926989165
B5	0.000462871123454
C#6	0.000075570795666

Figure a1.3. ***Eh***

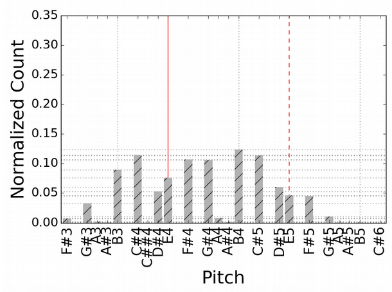

Figure a1.4. ***Xp***

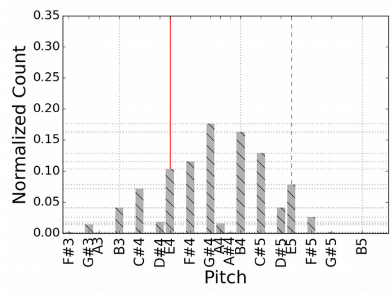

Table a1.3. ***Eh***

F#3	0.00742275159675
G#3	0.0333160711203
A3	0.00186048295836
A#3	0.000383604733682
B3	0.0891497401078
C#4	0.114403718409
C##4	0.0000767209467365
D#4	0.0529246664237
E4	0.0765802916675
F#4	0.107348588015
G#4	0.105890890027
A4	0.00838176343096
A#4	0.00126589562115
B4	0.12359105178
C#5	0.113288067975
D#5	0.0608013502887
E5	0.0463682221839
F#5	0.0456873237816
G#5	0.0105587202946
A5	0.000153441893473
A#5	0.000191802366841
B5	0.000450735562077
C#6	0.0000767209467365

Table a1.4. ***Xp***

F#3	0.00159733777038
G#3	0.0137865462325
A3	0.000855716662705
B3	0.0413025909199
C#4	0.0720513429998
D#4	0.0183503684336
E4	0.103969574519
F#4	0.115512241502
G#4	0.176705490849
A4	0.0160019015926
A#4	0.00150225814119
B4	0.163042548134
C#5	0.128604706442
D#5	0.0413216068457
E5	0.0779557879724
F#5	0.0256429759924
G#5	0.00177798906584
B5	0.0000190159258379

Figure a1.5. *Ls Eh*

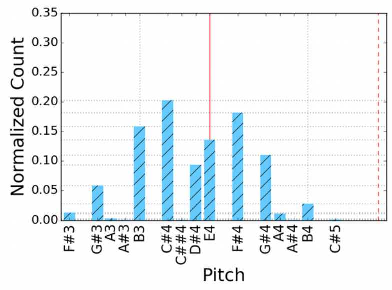

Table a1.5. *Ls Eh*

F#3	0.0131708811217
G#3	0.0591158152673
A3	0.00330122860157
A#3	0.000680665691046
B3	0.158186706599
C#4	0.202997197926
C##4	0.000136133138209
D#4	0.0938411099389
E4	0.135883560789
F#4	0.181783117222
G#4	0.109893475819
A4	0.0110267841949
A#4	0.000408399414628
B4	0.0280774597556
C#5	0.0014974645203

Figure a1.6. *Ls Xp*

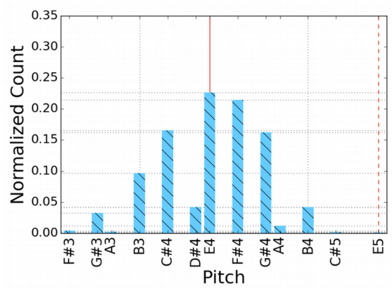

Table a1.6. *Ls Xp*

F#3	0.00374815938602
G#3	0.0323501851769
A3	0.00200794252822
B3	0.0968274508054
C#4	0.16505287582
D#4	0.0419883093124
E4	0.226495917184
F#4	0.214582124849
G#4	0.16197403061
A4	0.0116014457186
B4	0.041720583642
C#5	0.00120476551693
E5	0.000446209450716

Figure a1.7. ***Da Eh***

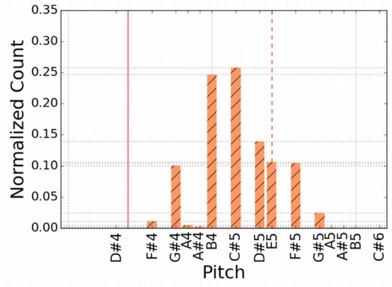

Table a1.7. ***Da Eh***

D#4	0.0000878966335589
F#4	0.0112287949372
G#4	0.100722217339
A4	0.00496615979608
A#4	0.00237320910609
B4	0.246930942545
C#5	0.25764700712
D#5	0.139316164191
E5	0.106245055814
F#5	0.104684890569
G#5	0.0241935483871
A5	0.000351586534236
A#5	0.0000439483167795
B5	0.00103278544432
C#6	0.000175793267118

Figure a1.8. ***Da Xp***

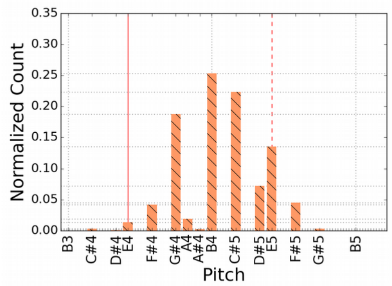

Table a1.8. ***Da Xp***

B3	0.0000662767385217
C#4	0.00298245323348
D#4	0.00079532086226
E4	0.0129736715656
F#4	0.0419366062996
G#4	0.18764601594
A4	0.0192699617252
A#4	0.00261793117161
B4	0.253144002784
C#5	0.223220055341
D#5	0.0720096764038
E5	0.135519361092
F#5	0.0446870909483
G#5	0.00309843752589
B5	0.0000331383692608

Figure a1.9. *Ls Eh* Yb

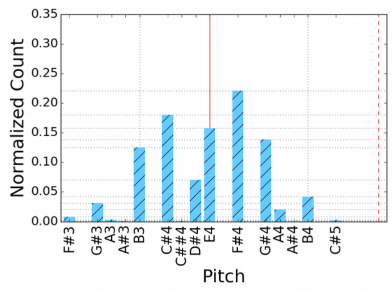

Table a1.9. *Ls Eh* Yb

F#3	0.00766043930274
G#3	0.0310325959509
A3	0.00289220667553
A#3	0.000625341983897
B3	0.125068396779
C#4	0.179942155866
C##4	0.000312670991949
D#4	0.0700383021965
E4	0.157508012194
F#4	0.221058391308
G#4	0.138825920425
A4	0.0201672789807
A#4	0.000312670991949
B4	0.0421324161651
C#5	0.0024232001876

Figure a1.10. *Ls Eh* Yb O1

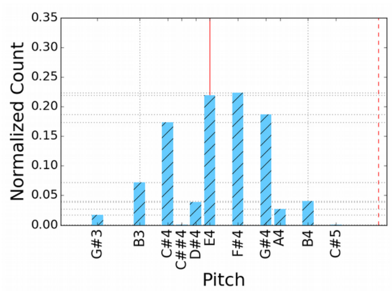

Table a1.10. *Ls Eh* Yb O1

G#3	0.0170717011448
B3	0.0717011448082
C#4	0.173729664591
C##4	0.00080337417152
D#4	0.0387628037759
E4	0.218919461739
F#4	0.223739706768
G#4	0.186784494878
A4	0.0271138782888
B4	0.0405703956618
C#5	0.00080337417152

Figure a1.11. *Ls Eh* Yb O2

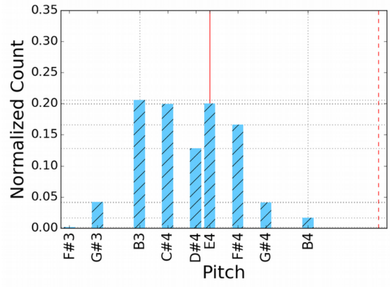

Table a1.11. *Ls Eh* Yb O2

F#3	0.00128040973111
G#3	0.0416133162612
B3	0.205505761844
C#4	0.199743918054
D#4	0.128040973111
E4	0.200384122919
F#4	0.165813060179
G#4	0.0409731113956
B4	0.0166453265045

Figure a1.12. *Ls Eh* Yb C

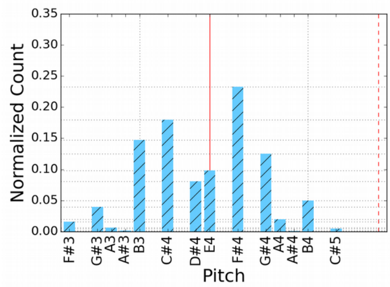

Table a1.12. *Ls Eh* Yb C

F#3	0.0153550863724
G#3	0.0395073576456
A3	0.00591810620601
A#3	0.00127959053103
B3	0.147472808701
C#4	0.179942418426
D#4	0.0804542546385
E4	0.0978886756238
F#4	0.232725527831
G#4	0.125079974408
A4	0.0196737044146
A#4	0.000639795265515
B4	0.0497440818938
C#5	0.00431861804223

Figure a1.13. *Ls Xp* Yb

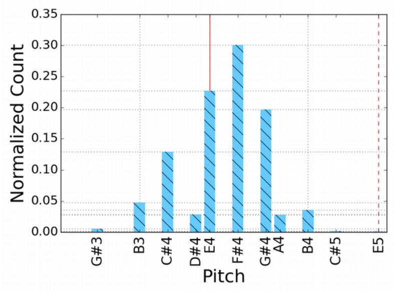

Table a1.13. *Ls Xp* Yb

G#3	0.00528973310892
B3	0.0476075979803
C#4	0.128877133926
D#4	0.0283722048569
E4	0.22721808127
F#4	0.300553017552
G#4	0.1969223371
A4	0.0278913200289
B4	0.0355854772782
C#5	0.00120221207021
E5	0.000480884828084

Figure a1.14. *Ls Xp* Yb O

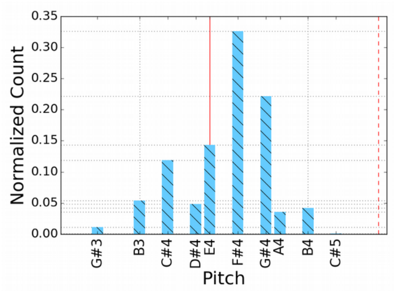

Table a1.14. *Ls Xp* Yb O

G#3	0.0109398309299
B3	0.0537046245649
C#4	0.11834908006
D#4	0.0482347091
E4	0.143212332173
F#4	0.326205867727
G#4	0.221282943809
A4	0.035305818001
B4	0.0417702635505
C#5	0.000994530084535

Figure a1.15. ***Ls Xp*** **Yb C**

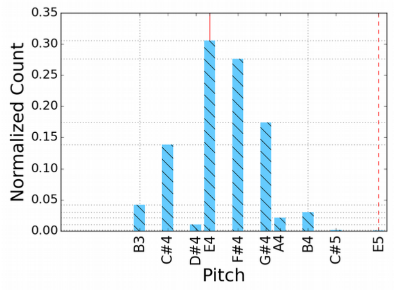

Table a1.15. ***Ls Xp*** **Yb C**

B3	0.0418994413408
C#4	0.138733705773
D#4	0.00977653631285
E4	0.305865921788
F#4	0.276536312849
G#4	0.174115456238
A4	0.0209497206704
B4	0.0297951582868
C#5	0.00139664804469
E5	0.000931098696462

Figure a1.16. ***Da Eh*** **Yb**

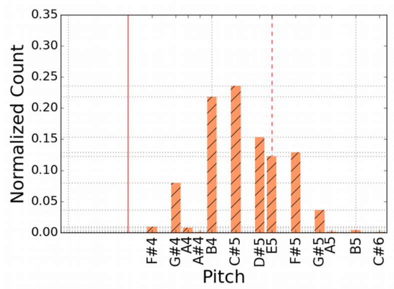

Table a1.16. ***Da Eh*** **Yb**

F#4	0.00952751312464
G#4	0.0801088858643
A4	0.00758312269104
A#4	0.0009721952168
B4	0.218355045693
C#5	0.236243437682
D#5	0.153606844254
E5	0.122302158273
F#5	0.129107524791
G#5	0.0359712230216
A5	0.00155551234688
B5	0.0038887808672
C#6	0.00077775617344

Figure a1.17. ***Da Eh*** **Yb O1**

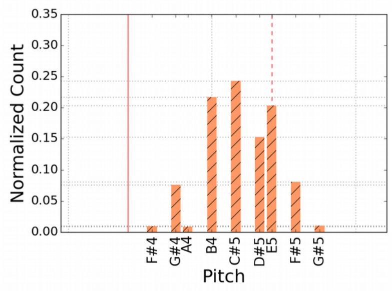

Table a1.17. ***Da Eh*** **Yb O1**

F#4	0.00910364145658
G#4	0.0756302521008
A4	0.00840336134454
B4	0.217086834734
C#5	0.24299719888
D#5	0.152661064426
E5	0.203781512605
F#5	0.0805322128852
G#5	0.00980392156863

Figure a1.18. ***Da Eh*** **Yb O2**

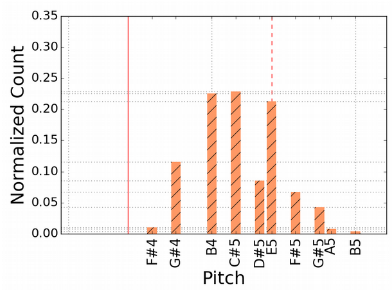

Table a1.18. ***Da Eh*** **Yb O2**

F#4	0.010060362173
G#4	0.11569416499
B4	0.225352112676
C#5	0.228370221328
D#5	0.0855130784708
E5	0.213279678068
F#5	0.0674044265594
G#5	0.0422535211268
A5	0.00804828973843
B5	0.00402414486922

Figure a1.19. ***Da Eh*** **Yb C**

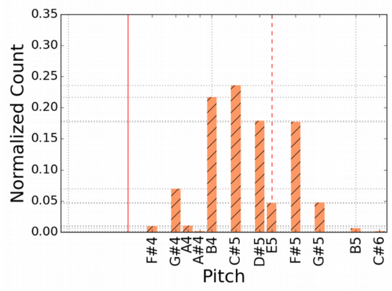

Table a1.19. ***Da Eh*** **Yb C**

F#4	0.00955531054759
G#4	0.0694597574421
A4	0.00992282249173
A#4	0.00183755972069
B4	0.216464535097
C#5	0.235575156193
D#5	0.178978316795
E5	0.0463065049614
F#5	0.177140757075
G#5	0.0474090407938
B5	0.00588019110621
C#6	0.00147004777655

Figure a1.20. ***Da Xp*** **Yb**

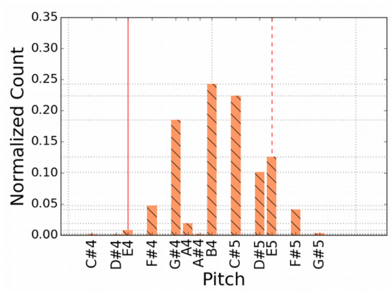

Table a1.20. ***Da Xp*** **Yb**

C#4	0.00108406425544
D#4	0.000788410367596
E4	0.00788410367596
F#4	0.0476988272396
G#4	0.185227160737
A4	0.0186754705824
A#4	0.00128116684734
B4	0.242633290628
C#5	0.223908544397
D#5	0.101113629644
E5	0.125850004928
F#5	0.040997339115
G#5	0.00285798758254

Figure a1.21. ***Da Xp*** **Yb O**

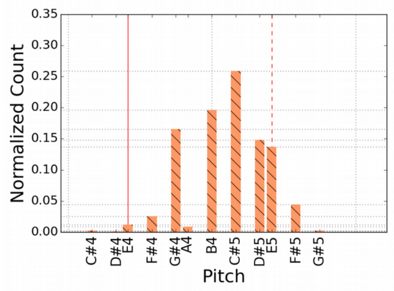

Table a1.21. ***Da Xp*** **Yb O**

C#4	0.00227531285552
D#4	0.000827386492916
E4	0.0119971041473
F#4	0.0254421346572
G#4	0.16527045196
A4	0.00848071155238
B4	0.196297445444
C#5	0.258971972283
D#5	0.147895335609
E5	0.136725617954
F#5	0.0439549074361
G#5	0.00186161960906

Figure a1.22. ***Da Xp*** **Yb C**

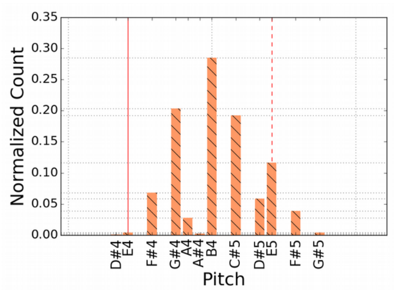

Table a1.22. ***Da Xp*** **Yb C**

D#4	0.000752941176471
E4	0.00414117647059
F#4	0.0679529411765
G#4	0.203388235294
A4	0.0279529411765
A#4	0.00244705882353
B4	0.2848
C#5	192
D#5	0.0585411764706
E5	0.115952941176
F#5	0.0383058823529
G#5	0.00376470588235

Figure a1.23. *Ls Eh* Mb

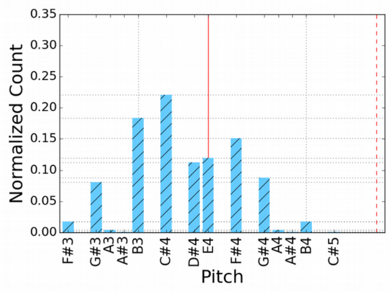

Table a1.23. *Ls Eh* Mb

F#3	0.01742013261
G#3	0.080771549126
A3	0.00361663652803
A#3	0.000723327305606
B3	0.183725135624
C#4	0.220775567611
D#4	0.11219610207
E4	0.119208358449
F#4	0.151496885674
G#4	0.0875828812538
A4	0.00397830018083
A#4	0.000482218203737
B4	0.0172393007836
C#5	0.000783604581073

Figure a1.24. *Ls Eh* Mb O1

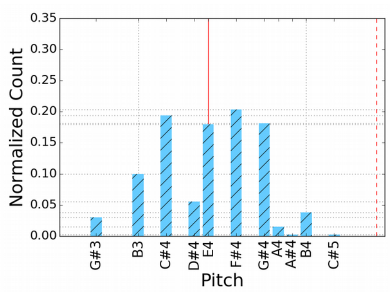

Table a1.24. *Ls Eh* Mb O1

G#3	0.0297433437275
B3	0.0993043895419
C#4	0.19413128648
D#4	0.0554089709763
E4	0.179259614616
F#4	0.203725913488
G#4	0.181578316143
A4	0.015111537539
A#4	0.00191892540178
B4	0.0378987766851
C#5	0.00191892540178

Figure a1.25. *Ls Eh* Mb O2

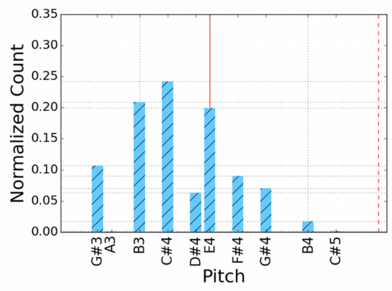

Table a1.25. *Ls Eh* Mb O2

G#3	0.106851348009
A3	0.000494682166708
B3	0.209003215434
C#4	0.242559155742
D#4	0.0630719762553
E4	0.199521807239
F#4	0.0899497073131
G#4	0.0702448676725
B4	0.0170665347514
C#5	0.00123670541677

Figure a1.26. *Ls Eh* Mb C

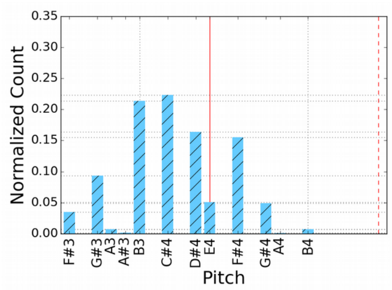

Table a1.26. *Ls Eh* Mb C

F#3	0.0344951062306
G#3	0.0935784196706
A3	0.00692289329196
A#3	0.00143232275006
B3	0.213535449988
C#4	0.223521922495
D#4	0.164160101854
E4	0.0505689504257
F#4	0.155208084666
G#4	0.0491764144187
A4	0.000358080687515
B4	0.00704225352113

Figure a1.27. ***Ls Xp*** **Mb**

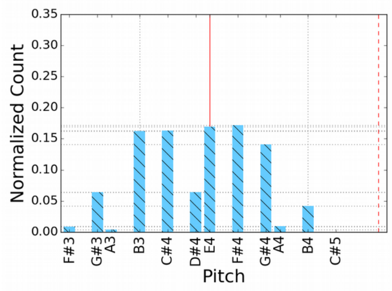

Table a1.27. ***Ls Xp*** **Mb**

F#3	0.00887183790912
G#3	0.063661431483
A3	0.00419613955161
B3	0.162450545498
C#4	0.163169883707
D#4	0.0642608799904
E4	0.169524037885
F#4	0.171921831915
G#4	0.141110178636
A4	0.00911161731207
B4	0.0414818367102
C#5	0.000239779402949

Figure a1.28. ***Ls Xp*** **Mb O**

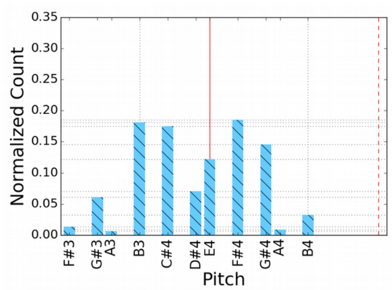

Table a1.28. ***Ls Xp*** **Mb O**

F#3	0.0134103184951
G#3	0.0605326876513
A3	0.00651890482399
B3	0.181598062954
C#4	0.17507915813
D#4	0.0705904265226
E4	0.121810392997
F#4	0.184950642578
G#4	0.145278450363
A4	0.00819519463587
B4	0.0320357608493

Figure a1.29. ***Ls Xp*** **Mb C**

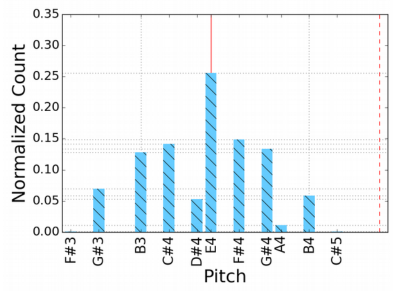

Table a1.29. ***Ls Xp*** **Mb C**

F#3	0.000672947510094
G#3	0.0693135935397
B3	0.127860026918
C#4	0.141655450875
D#4	0.0528263795424
E4	0.255720053836
F#4	0.148384925976
G#4	0.133580080754
A4	0.0107671601615
B4	0.0585464333782
C#5	0.000672947510094

Figure a1.30. ***Da Eh*** **Mb**

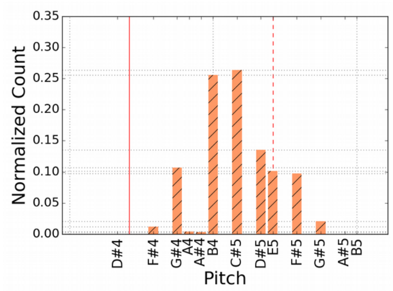

Table a1.30. ***Da Eh*** **Mb**

D#4	0.000113565385271
F#4	0.0117256260292
G#4	0.106741998372
A4	0.00420191925501
A#4	0.00278235193913
B4	0.255276058524
C#5	0.263897564022
D#5	0.135142808472
E5	0.101555845778
F#5	0.0975526659474
G#5	0.0207540741582
A#5	0.0000567826926353
B5	0.000198739424223

Figure a1.31. ***Da Eh*** **Mb O1**

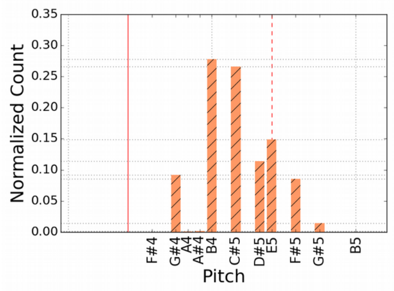

Table a1.31. ***Da Eh*** **Mb O1**

F#4	0.000160875160875
G#4	0.0918865293865
A4	0.000482625482625
A#4	0.00160875160875
B4	0.277482839983
C#5	0.266007078507
D#5	0.113819176319
E5	0.149050836551
F#5	0.0855855855856
G#5	0.0138352638353
B5	0.0000804375804376

Figure a1.32. ***Da Eh*** **Mb O2**

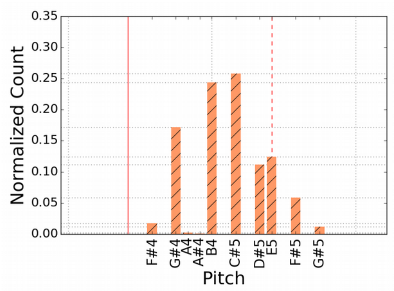

Table a1.32. ***Da Eh*** **Mb O2**

F#4	0.017130620985
G#4	0.171663097787
A4	0.00214132762313
A#4	0.000356887937188
B4	0.243932905068
C#5	0.257851534618
D#5	0.11170592434
E5	0.124553890079
F#5	0.0585296216988
G#5	0.0121341898644

Figure a1.33. *Da Eh* Mb C

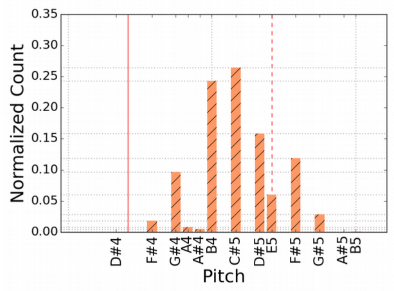

Table a1.33. *Da Eh* Mb C

D#4	0.000232747585244
F#4	0.0183288723379
G#4	0.0963187090267
A4	0.00756429652042
A#4	0.00442220411963
B4	0.242910896466
C#5	0.264343069941
D#5	0.158210171069
E5	0.059699755615
F#5	0.11893401606
G#5	0.0285697660887
A#5	0.000116373792622
B5	0.000349121377866

Figure a1.34. *Da Xp* Mb

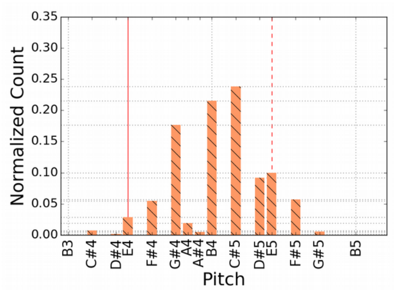

Table a1.34. *Da Xp* Mb

B3	0.000195608587217
C#4	0.00674849625899
D#4	0.00156486869774
E4	0.0283143429997
F#4	0.0547215022739
G#4	0.17658565211
A4	0.0192674458409
A#4	0.00489021468042
B4	0.215658467407
C#5	0.238593574258
D#5	0.0913981123771
E5	0.100004890215
F#5	0.0567264902929
G#5	0.00523252970805
B5	0.0000978042936085

Figure a1.35. *Da Xp* Mb O

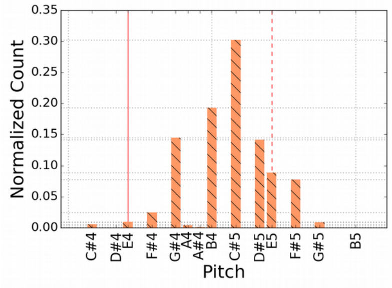

Table a1.35. *Da Xp* Mb O

C#4	0.00575480423389
D#4	0.000205528722639
E4	0.00945432124139
F#4	0.0240468605488
G#4	0.145000513822
A4	0.0036995170075
A#4	0.000411057445278
B4	0.192785941835
C#5	0.302538279725
D#5	0.141403761176
E5	0.0888911725414
F#5	0.0773815640736
G#5	0.00822114890556
B5	0.000205528722639

Figure a1.36. *Da Xp* Mb C

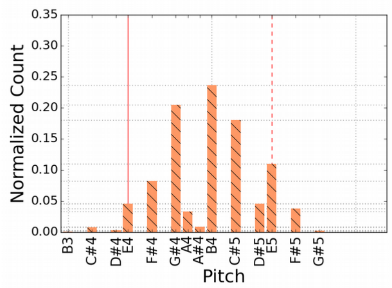

Table a1.36. *Da Xp* Mb C

B3	0.000373203955962
C#4	0.00765068109722
D#4	0.00279902966971
E4	0.0454375816384
F#4	0.0825713752566
G#4	0.205262175779
A4	0.0334017540586
A#4	0.00895689494309
B4	0.236424706102
C#5	0.180537413697
D#5	0.0459973875723
E5	0.110095167009
F#5	0.0379735025191
G#5	0.00251912670274

Figure a1.37. *Ls Xp* Kb

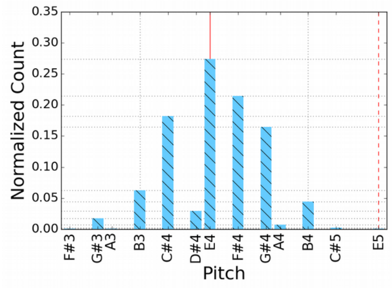

Table a1.37. *Ls Xp* Kb

F#3	0.0010089799213
G#3	0.0173544546464
A3	0.0010089799213
B3	0.0622540611442
C#4	0.181818181818
D#4	0.0289577237413
E4	0.274139844617
F#4	0.214408233276
G#4	0.16486731914
A4	0.00686106346484
B4	0.0444960145293
C#5	0.0020179598426
E5	0.00080718393704

Figure a1.38. *Ls Xp* Kb O

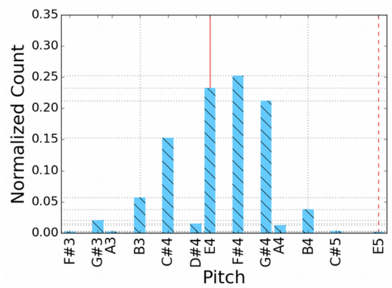

Table a1.38. *Ls Xp* Kb O

F#3	0.00192604006163
G#3	0.0204160246533
A3	0.00192604006163
B3	0.056625577812
C#4	0.152542372881
D#4	0.0146379044684
E4	0.232473035439
F#4	0.252696456086
G#4	0.212249614792
A4	0.0123266563945
B4	0.0375577812018
C#5	0.00308166409861
E5	0.00154083204931

Figure a1.39. ***Ls Xp*** **Kb C**

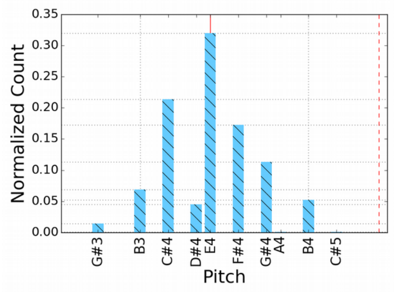

Table a1.39. ***Ls Xp*** **Kb C**

G#3	0.013986013986
B3	0.0684467048103
C#4	0.214028395847
D#4	0.0447128628947
E4	0.319983047256
F#4	0.172282263191
G#4	0.112735749099
A4	0.000847637211274
B4	0.0521296884933
C#5	0.000847637211274

Figure a1.40. ***Da Xp*** **Kb**

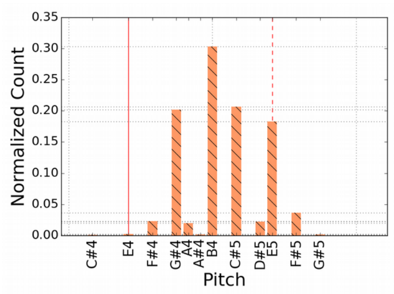

Table a1.40. ***Da Xp*** **Kb**

C#4	0.00101988781234
E4	0.00224375318715
F#4	0.022641509434
G#4	0.20168281489
A4	0.0198878123406
A#4	0.00163182049975
B4	0.303110657828
C#5	0.206476287608
D#5	0.0216726160122
E5	0.182559918409
F#5	0.035951045385
G#5	0.00112187659357

Figure a1.41. ***Da Xp*** **Kb O**

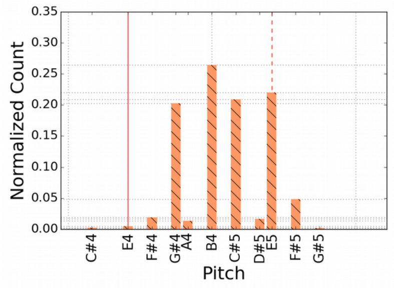

Table a1.41. ***Da Xp*** **Kb O**

C#4	0.00221975582686
E4	0.00488346281909
F#4	0.0186459489456
G#4	0.202219755827
A4	0.0133185349612
B4	0.264150943396
C#5	0.208879023307
D#5	0.0165371809101
E5	0.219755826859
F#5	0.0480577136515
G#5	0.00133185349612

Figure a1.42. ***Da Xp*** **Kb C**

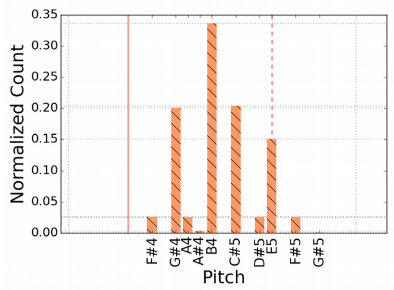

Table a1.42. ***Da Xp*** **Kb C**

F#4	0.0260377358491
G#4	0.201226415094
A4	0.0254716981132
A#4	0.00301886792453
B4	0.336226415094
C#5	0.204433962264
D#5	0.0260377358491
E5	0.150943396226
F#5	0.0256603773585
G#5	0.000943396226415

a2. Pitch histograms per line sections

Table columns 2 to 4 correspond respectively to each of the three line sections that appear in the plot.

Figure a2.1. ***Ls***

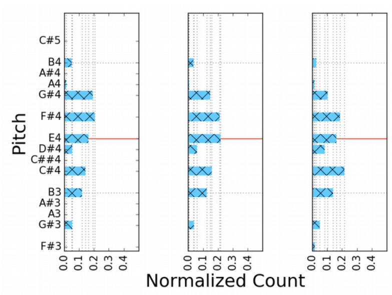

Table a2.1. Ls

F#3	0.00018573551263	0.0031078760121	0.0149959987474
G#3	0.0550705794948	0.0384395190971	0.0484325527991
A3	--	0.00130857937352	0.00438398107234
A#3	--	--	0.000695870011482
B3	0.119242199108	0.125051116382	0.139313176299
C#4	0.142366270431	0.157683814509	0.215742899226
C##4	--	--	0.000139174002296
D#4	0.0546062407132	0.0588042855974	0.0832028577062
E4	0.162394749876	0.216160955263	0.162346473679
F#4	0.204804358593	0.21002698945	0.186006054069
G#4	0.194186478455	0.147378751942	0.102988761699
A4	0.0130014858841	0.00449824159647	0.0135346717233
A#4	0.00074294205052	--	0.000139174002296
B4	0.0515416047548	0.0349227120308	0.0270693434466
C#5	0.0018573551263	0.00229001390366	0.000800250513204
E5	--	0.000327144843379	0.000208761003445

Figure a2.2. ***Da***

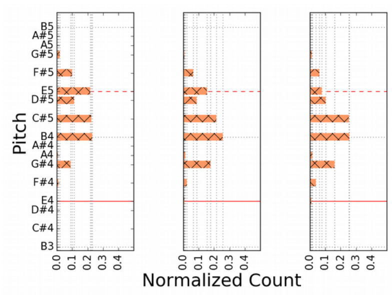

Table a2.2. ***Da***

B3	--	0.0000833333333333	0.000033373381391
C#4	--	0.00241666666667	0.00203577626485
D#4	0.000182498403139	0.0005	0.000600720865038
E4	0.000364996806278	0.00516666666667	0.0108630356428
F#4	0.00757368373027	0.0206666666667	0.0397143238553
G#4	0.0894242175381	0.177166666667	0.161721843991
A4	0.00474495848161	0.0115	0.0168368709118
A#4	--	0.00125	0.00393805900414
B4	0.229765489552	0.254625	0.256279757932
C#5	0.22269367643	0.213333333333	0.253570951809
D#5	0.111552148919	0.086875	0.102723267922
E5	0.216579979925	0.152791666667	0.0767587771993
F#5	0.0985947622958	0.0648333333333	0.062474969964
G#5	0.0185235879186	0.00770833333333	0.0116306234148
A5	--	0.000666666666667	--
A#5	--	--	0.000033373381391
B5	--	0.000416666666667	0.000650780937125
C#6	--	--	0.000133493525564

Figure a2.3. *Eh*

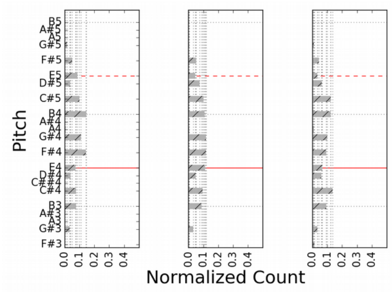

Table a2.3. Eh

F#3	--	0.000183460991607	0.0123670938935
G#3	0.0347401951025	0.0305462551025	0.0336641932479
A3	--	--	0.00311586521474
A#3	--	--	0.000642446436028
B3	0.075851085009	0.0891620419208	0.0935723234075
C#4	0.0772446744973	0.0933816447278	0.13390725215
C##4	--	--	0.000128489287206
D#4	0.0398168425244	0.0488006237674	0.0586981893718
E4	0.0734288937554	0.110993899922	0.0653368025441
F#4	0.144269692747	0.117690226116	0.0910185988243
G#4	0.111437388015	0.119020318305	0.0994935380596
A4	0.00617161059128	0.00357748933633	0.0107931001253
A#4	0.000796336850488	0.000642113470623	0.00163823841187
B4	0.147670714712	0.106590836123	0.122005931922
C#5	0.0993927931515	0.0996651836903	0.122755452764
D#5	0.0356858451125	0.074622758336	0.0641803989592
E5	0.0864523193311	0.0459569783975	0.0336641932479
F#5	0.0503185347402	0.0513690776499	0.0422890366516
G#5	0.0167230738602	0.00660459569784	0.00997398091934
A5	--	0.000733843966427	--
A#5	--	--	0.0000321223218014
B5	--	0.000458652479017	0.000594262953326
C#6	--	--	0.000128489287206

Figure a2.4. ***Xp***

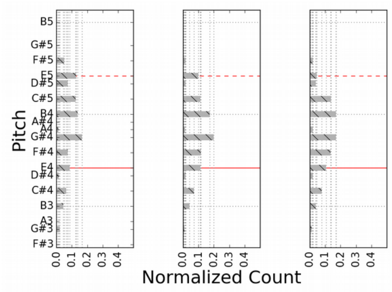

Table a2.4. Xp

F#3	0.000171218217618	0.00270158718247	0.0016682381954
G#3	0.0208886225494	0.0102810401111	0.0124755204178
A3	--	0.00120070541443	0.00105171538406
B3	0.0446879547984	0.0418746013283	0.0396025241169
C#4	0.0648060953685	0.0704663990094	0.0759048378908
D#4	0.0162657306737	0.0144835090616	0.0211068397766
E4	0.0868932454413	0.112190912161	0.10725683615
F#4	0.0718260422909	0.11504258752	0.134275041706
G#4	0.167066175841	0.197403474541	0.170758685718
A4	0.0111291841452	0.0115567896139	0.0202183216073
A#4	--	0.000600352707215	0.00257488938855
B4	0.136075678452	0.174139807137	0.168963516356
C#5	0.125160517079	0.112678698736	0.137792848335
D#5	0.0739662700111	0.017185096244	0.0391673315442
E5	0.128841708758	0.100296424149	0.0456226880395
F#5	0.0492252375653	0.0163596112716	0.0201457895119
G#5	0.00299631880832	0.00153840381224	0.00137810981359
B5	--	--	0.0000362660477261

Figure a2.5. *Ls Eh*

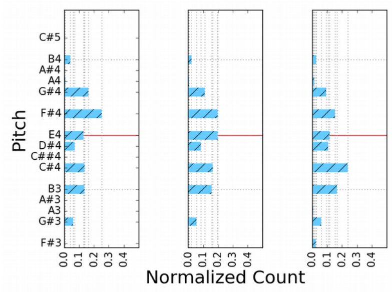

Table a2.5. *Ls Eh*

F#3	--	0.000323991576219	0.0220037720752
G#3	0.0617152961981	0.0539445974405	0.0598959821684
A3	--	--	0.00554380750986
A#3	--	--	0.00114305309482
B3	0.13474801061	0.157459906042	0.16648568326
C#4	0.137223695844	0.164911712295	0.23825036673
C##4	--	--	0.000228610618963
D#4	0.0703801945181	0.0861817592743	0.104436951096
E4	0.130445033893	0.196014903613	0.116248499743
F#4	0.253639846743	0.197148874129	0.151968908956
G#4	0.161450044209	0.112425076948	0.0923586900612
A4	0.00707338638373	0.00566985258383	0.0142310110305
A#4	0.00141467727675	--	0.000228610618963
B4	0.0403183023873	0.0226794103353	0.0261187632166
C#5	0.00159151193634	0.00323991576219	0.000857289821112

Figure a2.6. ***Ls Xp***

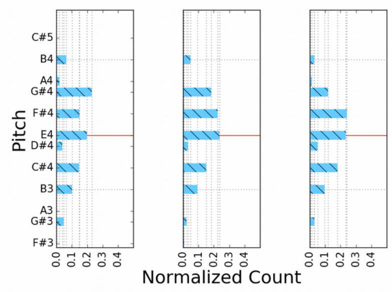

Table a2.6. ***Ls Xp***

F#3	0.000391159788774	0.00594648166501	0.00409107079331
G#3	0.0477214942304	0.0226296663363	0.0305940946282
A3	--	0.00264288074001	0.00257915332622
B3	0.10209270487	0.0920052857615	0.0970295268588
C#4	0.148053980051	0.150313842088	0.180718605478
D#4	0.0371601799335	0.0308886686488	0.0501600853789
E4	0.197731273225	0.236703006277	0.234080398435
F#4	0.150792098572	0.223158242484	0.238971896122
G#4	0.230393115588	0.183019491245	0.119530416222
A4	0.0195579894387	0.00330360092501	0.0124510850231
B4	0.0639546254645	0.0474066732739	0.0285485592316
C#5	0.00215137883826	0.00132144037	0.00071149057275
E5	--	0.000660720185002	0.000533617929562

Figure a2.7. ***Da Eh***

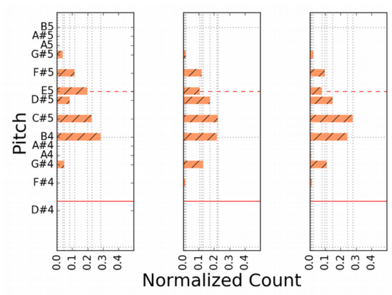

Table a2.7. ***Da Eh***

D#4	0.000455477112275	--	--
F#4	0.00341607834206	0.0139579147721	0.0127988851401
G#4	0.0470280118424	0.127630326742	0.108649943768
A4	0.00501024823503	0.000845934228614	0.00638110605838
A#4	--	0.00148038490007	0.00344726419246
B4	0.285925757231	0.216136195411	0.245061366192
C#5	0.225347301298	0.225547213704	0.279191726566
D#5	0.0816442723753	0.172041873744	0.146545401203
E5	0.197790936005	0.105953262134	0.0768666568872
F#5	0.115121840128	0.118430792006	0.0965600704122
G#5	0.0382600774311	0.015226816115	0.0227739474842
A5	--	0.00169186845723	--
A#5	--	--	0.0000733460466481
B5	--	0.00105741778577	0.00135690186299
C#6	--	--	0.000293384186592

Figure a2.8. ***Da Xp***

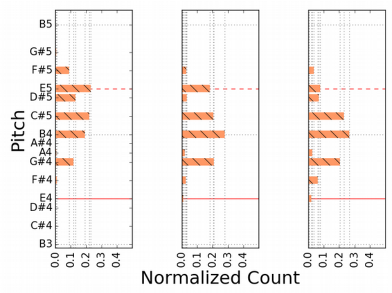

Table a2.8. ***Da Xp***

B3	--	0.000137523207041	0.0000612369871402
C#4	--	0.00398817300419	0.00373545621555
D#4	--	0.000825139242247	0.00110226576852
E4	0.000609013398295	0.00852643883655	0.0199326393141
F#4	0.010353227771	0.0250292236815	0.0621861604409
G#4	0.117767965895	0.20937908272	0.206031843233
A4	0.00456760048721	0.0184281097435	0.025566442131
A#4	--	0.00110018565633	0.00434782608696
B4	0.192219853837	0.279653441518	0.265646050214
C#5	0.220919610231	0.205390909716	0.232180036742
D#5	0.131546894032	0.0314928144124	0.0661359461115
E5	0.229141291108	0.183249673382	0.0766687078996
F#5	0.0875456760049	0.029980059135	0.0340171463564
G#5	0.00532886723508	0.00281922574434	0.00232700551133
B5	--	--	0.0000612369871402

Figure a2.9. *Ls Eh* Yb

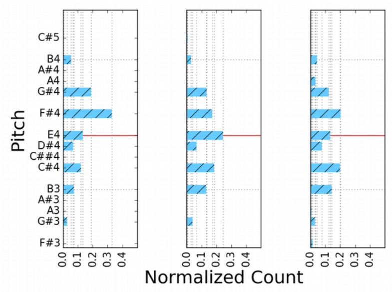

Table a2.9. *Ls Eh* Yb

F#3	--	0.00070003500175	0.0130417062899
G#3	0.0274941084053	0.0385019250963	0.0293438391523
A3	--	--	0.0050264909659
A#3	--	--	0.00108680885749
B3	0.0730557737628	0.131256562828	0.141149300367
C#4	0.121366849961	0.183409170459	0.19942942535
C##4	--	--	0.000543404428746
D#4	0.0652003142184	0.0633531676584	0.0745822578454
E4	0.133935585232	0.245012250613	0.131503871757
F#4	0.327965435978	0.170458522926	0.202146447494
G#4	0.190494893951	0.133006650333	0.123352805325
A4	0.00432050274941	--	0.0335552234751
A#4	--	--	0.000543404428746
B4	0.053809897879	0.0287014350718	0.0434723542997
C#5	0.00235663786332	0.005600280014	0.00122265996468

Figure a2.10. ***Ls Eh*** **Yb O1**

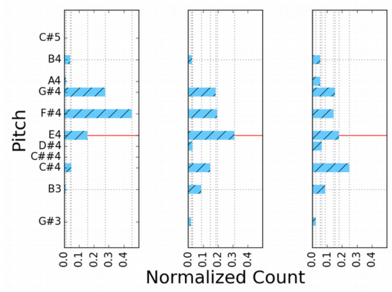

Figure a2.11. ***Ls Eh*** **Yb O2**

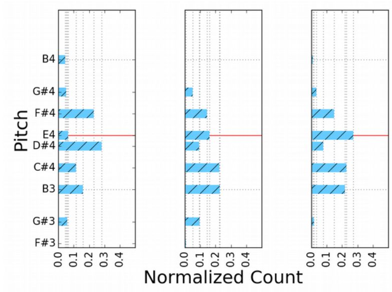

Table a2.10. ***Ls Eh*** **Yb O1**

G#3	--	0.0187651331719	0.0232458028412
B3	0.0102249488753	0.0883777239709	0.0865260439087
C#4	0.0470347648262	0.148305084746	0.247094274645
C##4	--	--	0.00172191132157
D#4	--	0.0290556900726	0.0624192854068
E4	0.155419222904	0.311138014528	0.179939733104
F#4	0.455010224949	0.195520581114	0.141196728368
G#4	0.277096114519	0.18401937046	0.151958674128
A4	0.0112474437628	--	0.0533792509686
B4	0.0419222903885	0.024818401937	0.051657339647
C#5	0.00204498977505	--	0.000860955660783

Table a2.11. ***Ls Eh*** **Yb O2**

F#3	--	0.00651465798046	--
G#3	0.0569105691057	0.0944625407166	0.0158371040724
B3	0.159891598916	0.228013029316	0.217194570136
C#4	0.113821138211	0.224755700326	0.227375565611
D#4	0.281842818428	0.0912052117264	0.0769230769231
E4	0.0623306233062	0.159609120521	0.272624434389
F#4	0.230352303523	0.14332247557	0.147058823529
G#4	0.0514905149051	0.0521172638436	0.0316742081448
B4	0.0433604336043	--	0.0113122171946

Figure a2.12. *Ls Eh* Yb C

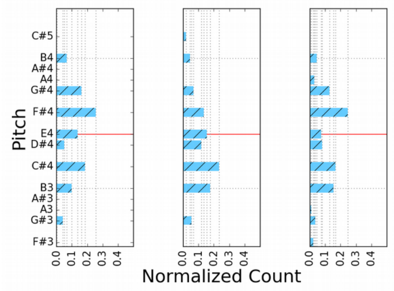

Table a2.12. *Ls Eh* Yb C

F#3	--	--	0.0231102551757
G#3	0.0408673894912	0.0556792873051	0.0356283100626
A3	--	--	0.00890707751565
A#3	--	--	0.00192585459798
B3	0.0975813177648	0.17706013363	0.155512758787
C#4	0.184320266889	0.233853006682	0.16682715455
D#4	0.0517097581318	0.116926503341	0.0808858931151
E4	0.138448707256	0.152561247216	0.0743861338469
F#4	0.254378648874	0.133630289532	0.24795377949
G#4	0.162635529608	0.0668151447661	0.126865671642
A4	--	--	0.0296100144439
A#4	--	--	0.000962927298989
B4	0.0667222685571	0.0456570155902	0.045739046702
C#5	0.00333611342786	0.0178173719376	0.00168512277323

Figure a2.13. ***Ls Xp*** **Yb**

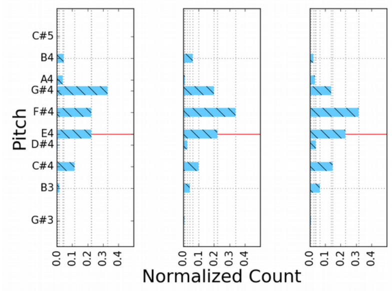

Figure a2.14. ***Ls Xp*** **Yb O**

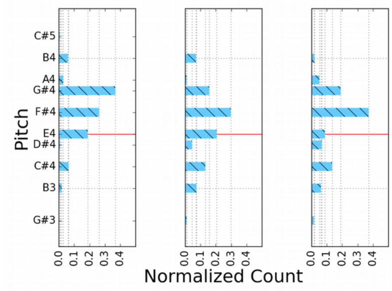

Table a2.13. ***Ls Xp*** **Yb**

G#3	--	0.0061919504644	0.00715243629861
B3	0.0167890870934	0.0412796697626	0.0634778721502
C#4	0.115424973767	0.0990712074303	0.147518998659
D#4	0.00629590766002	0.0247678018576	0.0393383996424
E4	0.223504721931	0.221878224974	0.231113097899
F#4	0.224554039874	0.338493292054	0.316495306214
G#4	0.329485834208	0.199174406605	0.139472507823
A4	0.0377754459601	0.00825593395253	0.0321859633438
B4	0.0430220356768	0.0608875128999	0.0214573088958
C#5	0.00314795383001	--	0.000894054537327
E5	--	--	0.000894054537327

Table a2.14. ***Ls Xp*** **Yb O**

G#3	--	0.0110091743119	0.0159680638723
B3	0.0172413793103	0.0733944954128	0.059880239521
C#4	0.0646551724138	0.132110091743	0.135728542914
D#4	0.00862068965517	0.0440366972477	0.0688622754491
E4	0.189655172414	0.205504587156	0.0878243512974
F#4	0.260775862069	0.297247706422	0.372255489022
G#4	0.366379310345	0.155963302752	0.189620758483
A4	0.0280172413793	0.0110091743119	0.0518962075848
B4	0.0603448275862	0.0697247706422	0.0179640718563
C#5	0.00431034482759	--	--

Figure a2.15. *Ls Xp* Yb C

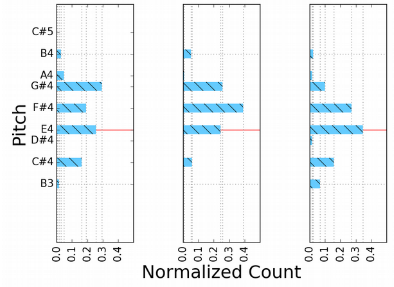

Table a2.15. *Ls Xp* Yb C

B3	0.0163599182004	--	0.0663967611336
C#4	0.163599182004	0.0566037735849	0.157085020243
D#4	0.0040899795501	--	0.0153846153846
E4	0.255623721881	0.242924528302	0.347368421053
F#4	0.19018404908	0.391509433962	0.271255060729
G#4	0.294478527607	0.254716981132	0.0987854251012
A4	0.0470347648262	0.00471698113208	0.0161943319838
B4	0.0265848670757	0.0495283018868	0.0242914979757
C#5	0.00204498977505	--	0.00161943319838
E5	--	--	0.00161943319838

Figure a2.16. ***Da Eh*** **Yb**

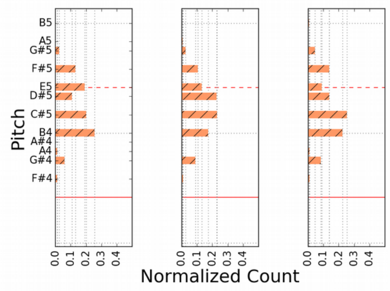

Table a2.16. ***Da Eh*** **Yb**

F#4	0.0118938700823	0.00798722044728	0.00929235167977
G#4	0.0612991765782	0.0894568690096	0.0832737669764
A4	0.0109789569991	--	0.0096497498213
A#4	--	--	0.00178699070765
B4	0.256175663312	0.174121405751	0.223373838456
C#5	0.201280878317	0.229233226837	0.253037884203
D#5	0.108874656908	0.226038338658	0.138670478914
E5	0.192131747484	0.13178913738	0.0907791279485
F#5	0.131747483989	0.105431309904	0.138670478914
G#5	0.0256175663312	0.0255591054313	0.0446747676912
A5	--	0.00638977635783	--
B5	--	0.00399361022364	0.00536097212294
C#6	--	--	0.00142959256612

Figure a2.17. *Da Eh* Yb O1

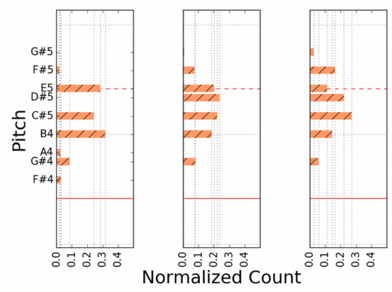

Figure a2.18. *Da Eh* Yb O2

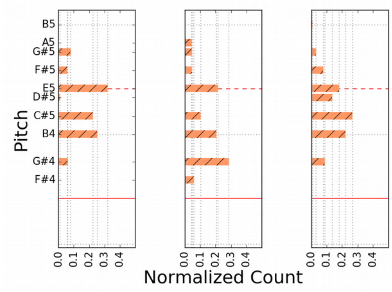

Table a2.17. *Da Eh* Yb O1

F#4	0.027027027027	--	--
G#4	0.0852390852391	0.0791896869245	0.0594059405941
A4	0.024948024948	--	--
B4	0.316008316008	0.184162062615	0.143564356436
C#5	0.243243243243	0.220994475138	0.272277227723
D#5	--	0.235727440147	0.222772277228
E5	0.284823284823	0.20073664825	0.111386138614
F#5	0.018711018711	0.073664825046	0.163366336634
G#5	--	0.00552486187845	0.0272277227723

Table a2.18. *Da Eh* Yb O2

F#4	--	0.0568181818182	--
G#4	0.0606060606061	0.284090909091	0.0854838709677
B4	0.252525252525	0.204545454545	0.222580645161
C#5	0.222222222222	0.102272727273	0.266129032258
D#5	0.010101010101	--	0.133870967742
E5	0.318181818182	0.215909090909	0.179032258065
F#5	0.0555555555556	0.0454545454545	0.0774193548387
G#5	0.0808080808081	0.0454545454545	0.0290322580645
A5	--	0.0454545454545	--
B5	--	--	0.00645161290323

Figure a2.19. ***Da Eh*** **Yb C**

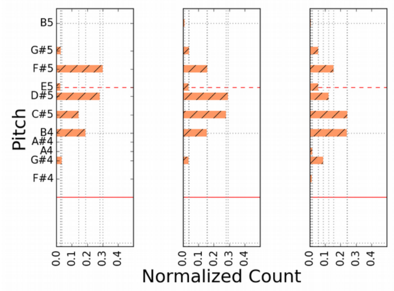

Table a2.19. ***Da Eh*** **Yb C**

F#4	--	--	0.0146561443067
G#4	0.0338164251208	0.0356472795497	0.0879368658399
A4	--	--	0.0152198421646
A#4	--	--	0.00281848928974
B4	0.188405797101	0.153846153846	0.24182638106
C#5	0.142512077295	0.279549718574	0.244081172492
D#5	0.282608695652	0.290806754221	0.121195039459
E5	0.024154589372	0.0337711069418	0.0552423900789
F#5	0.299516908213	0.157598499062	0.154453213078
G#5	0.0289855072464	0.0393996247655	0.054114994363
B5	--	0.0093808630394	0.00620067643743
C#6	--	--	0.00225479143179

Figure a2.20. ***Da Xp*** **Yb**

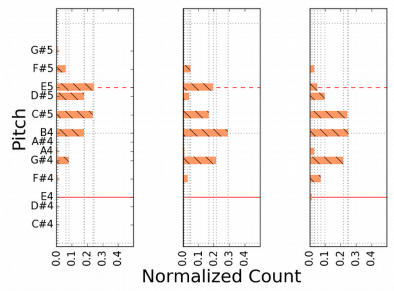

Table a2.20. ***Da Xp*** **Yb**

C#4	--	0.000877577885037	0.00162206001622
D#4	--	0.00175515577007	0.000720915562765
E4	0.00172450959258	0.00438788942519	0.0118951067856
F#4	0.0103470575555	0.0280824923212	0.0713706407137
G#4	0.0801896960552	0.215006581834	0.216905469947
A4	0.00646691097219	0.00789820096534	0.0282058213932
A#4	--	--	0.00234297557899
B4	0.178486742833	0.290478279947	0.249797242498
C#5	0.23496443199	0.167617376042	0.24240785798
D#5	0.177624488036	0.0383940324704	0.0948905109489
E5	0.241431342962	0.194822290478	0.0492024871587
F#5	0.0614356542358	0.0462922334357	0.0302784536361
G#5	0.00732916576848	0.00438788942519	0.000360457781382

Figure a2.21. ***Da Xp*** **Yb O**

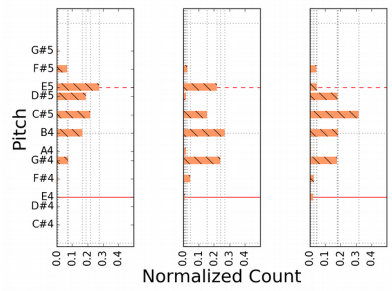

Table a2.21. ***Da Xp*** **Yb O**

C#4	--	0.0019512195122	0.00341038272073
D#4	--	0.00390243902439	--
E4	--	0.00975609756098	0.0181887078439
F#4	0.00512601452371	0.0458536585366	0.026525198939
G#4	0.0726185390859	0.239024390244	0.177718832891
A4	0.00256300726185	0.0156097560976	0.00833649109511
B4	0.165741136267	0.269268292683	0.181508147025
C#5	0.217855617258	0.153170731707	0.318302387268
D#5	0.189662537377	0.0165853658537	0.180371352785
E5	0.274241777018	0.216585365854	0.0447139067829
F#5	0.0670653566852	0.0253658536585	0.0409245926487
G#5	0.00512601452371	0.00292682926829	--

Figure a2.22. ***Da Xp*** **Yb C**

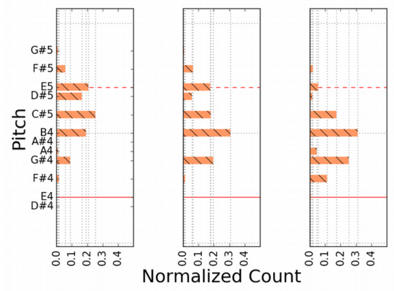

Table a2.22. ***Da Xp*** **Yb C**

D#4	--	--	0.00137480666781
E4	0.00348128807659	--	0.00618663000516
F#4	0.0156657963446	0.0135566188198	0.112046743427
G#4	0.0879025239339	0.195374800638	0.252448874377
A4	0.0104438642298	0.00159489633174	0.0462278742052
A#4	--	--	0.00446812167039
B4	0.191470844212	0.307814992026	0.311737411926
C#5	0.252393385553	0.179425837321	0.173569341811
D#5	0.165361183638	0.0562200956938	0.0173569341811
E5	0.208006962576	0.177033492823	0.0532737583777
F#5	0.0557006092254	0.0633971291866	0.0206221000172
G#5	0.00957354221062	0.00558213716108	0.000687403333906

Figure a2.23. ***Ls Eh*** **Mb**

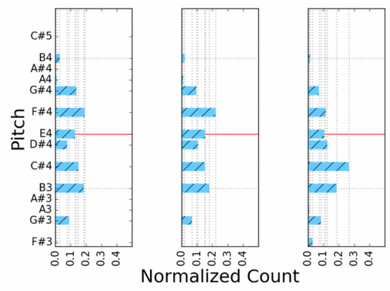

Table a2.23. ***Ls Eh*** **Mb**

F#3	--	--	0.0285122336227
G#3	0.0897394660663	0.0672496984318	0.0820836621942
A3	--	--	0.00591949486977
A#3	--	--	0.00118389897395
B3	0.185268575105	0.180036188179	0.184885556433
C#4	0.150209070441	0.148974668275	0.266443041305
D#4	0.0746220649727	0.105850422195	0.126118126809
E4	0.127586576606	0.153799758745	0.105169692186
F#4	0.192773667846	0.220144752714	0.115528808208
G#4	0.137664844001	0.0946924004825	0.0698500394633
A4	0.00932775812158	0.0105548854041	0.000197316495659
A#4	0.00257317465423	--	--
B4	0.0292698616919	0.0174909529554	0.0135161799526
C#5	0.000964940495336	0.00120627261761	0.000591949486977

Figure a2.24. ***Ls Eh*** **Mb O1**

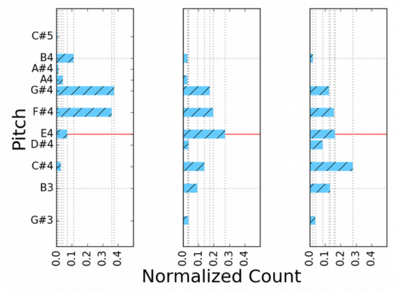

Figure a2.25. ***Ls Eh*** **Mb O2**

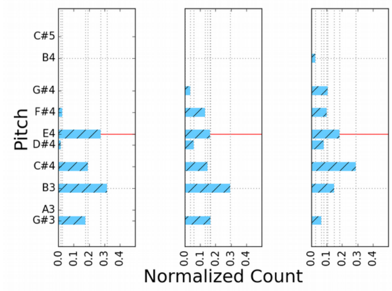

Table a2.24. *Ls Eh* Mb O1

G#3	--	0.0338436744561	0.0370537731586
B3	0.00287356321839	0.0942788074134	0.132851333032
C#4	0.0272988505747	0.137792103143	0.279409549631
D#4	--	0.0362610797744	0.0840488025305
E4	0.0689655172414	0.270749395649	0.162373851484
F#4	0.359195402299	0.195004029009	0.156951348095
G#4	375	0.173247381144	0.125621328513
A4	0.0402298850575	0.0282030620467	--
A#4	0.0114942528736	--	--
B4	0.110632183908	0.0282030620467	0.0207862629914
C#5	0.00431034482759	0.00241740531829	0.000903750564844

Table a2.25. *Ls Eh* Mb O2

G#3	0.175849941383	0.166666666667	0.0636400486421
A3	--	--	0.000810701256587
B3	0.317702227433	0.294117647059	0.147547628699
C#4	0.191090269637	0.148459383754	0.288474530469
D#4	0.0152403282532	0.0574229691877	0.081475476287
E4	0.274325908558	0.163865546218	0.184299418997
F#4	0.0257913247362	0.131652661064	0.0995811376841
G#4	--	0.0350140056022	0.104985812728
B4	--	0.00140056022409	0.027563842724
C#5	--	0.00140056022409	0.00162140251317

Figure a2.26. *Ls Eh* Mb C

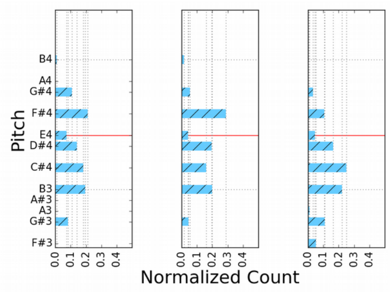

Table a2.26. *Ls Eh* Mb C

F#3	--	--	0.0529692082111
G#3	0.0826923076923	0.0455547391624	0.108687683284
A3	--	--	0.0106304985337
A#3	--	--	0.00219941348974
B3	0.194230769231	0.198383541514	0.222873900293
C#4	0.182692307692	0.159441587068	0.251221896383
D#4	0.140384615385	0.194709772226	0.163367546432
E4	0.0735042735043	0.0418809698751	0.0461876832845
F#4	0.209829059829	0.289493019838	0.105938416422
G#4	0.107051282051	0.0543717854519	0.0313416422287
A4	0.000641025641026	--	0.000366568914956
B4	0.00897435897436	0.0161645848641	0.00421554252199

Figure a2.27. *Ls Xp* Mb

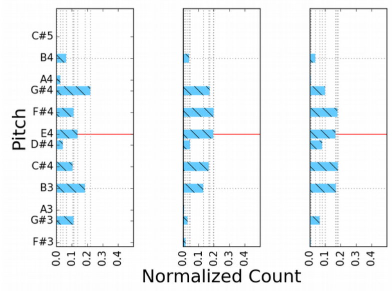

Table a2.27. *Ls Xp* Mb

F#3	0.0012987012987	0.0164383561644	0.00780741704619
G#3	0.11038961039	0.0296803652968	0.0641943179354
A3	--	0.00730593607306	0.00412058121882
B3	0.184415584416	0.131506849315	0.169811320755
C#4	0.105194805195	0.164840182648	0.18173931902
D#4	0.0415584415584	0.0447488584475	0.0811103882021
E4	0.138311688312	0.195433789954	0.167642593797
F#4	0.11038961039	0.197716894977	0.18022121015
G#4	0.219480519481	0.17397260274	0.0993276946432
A4	0.025974025974	--	0.00780741704619
B4	0.062987012987	0.0383561643836	0.0357839947951
C#5	--	--	0.000433745391455

Figure a2.28. *Ls Xp* Mb O

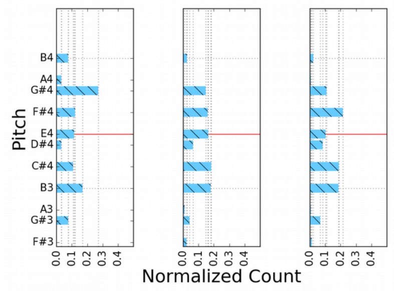

Table a2.28. *Ls Xp* Mb O

F#3	--	0.0231362467866	0.0119323831621
G#3	0.0753768844221	0.0417737789203	0.0662910175671
A3	--	0.0102827763496	0.00629764666888
B3	0.168341708543	0.179948586118	0.185946304276
C#4	0.108040201005	0.183161953728	0.188597944978
D#4	0.0326633165829	0.0629820051414	0.0845210473981
E4	0.115577889447	0.163881748072	0.101756711966
F#4	0.121859296482	0.161311053985	0.213788531654
G#4	0.27135678392	0.147814910026	0.110705999337
A4	0.0301507537688	--	0.00662910175671
B4	0.0766331658291	0.025706940874	0.0235333112363

Figure a2.29. *Ls Xp* Mb C

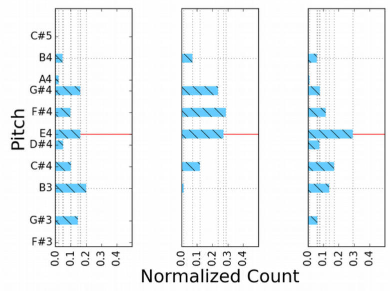

Table a2.29. *Ls Xp* Mb C

F#3	0.00268817204301	--	--
G#3	0.147849462366	--	0.060225846926
B3	0.201612903226	0.01261829653	0.139272271016
C#4	0.102150537634	0.119873817035	0.168757841907
D#4	0.0510752688172	--	0.0746549560853
E4	0.162634408602	0.272870662461	0.29234629862
F#4	0.0981182795699	0.287066246057	0.116687578419
G#4	0.163978494624	0.238170347003	0.077791718946
A4	0.0215053763441	--	0.0100376411543
B4	0.0483870967742	0.0694006309148	0.0589711417817
C#5	--	--	0.00125470514429

Figure a2.30. *Da Eh* Mb

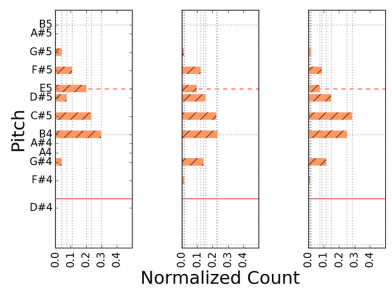

Table a2.30. *Da Eh* Mb

D#4	0.000606428138266	--	--
F#4	0.000606428138266	0.0161081547533	0.0137043189369
G#4	0.042298362644	0.141377822523	0.115202411714
A4	0.00303214069133	0.00115058248238	0.00553709856035
A#4	--	0.00201351934417	0.00387596899225
B4	0.295785324439	0.231267078959	0.250661375661
C#5	0.233323226198	0.224219761254	0.285944998154
D#5	0.0726197695573	0.152596001726	0.14857881137
E5	0.199666464524	0.0966489285201	0.0732742709487
F#5	0.109611885992	0.123112325615	0.0856866002215
G#5	0.0424499696786	0.0115058248238	0.0171188630491
A#5	--	--	0.0000922849760059
B5	--	--	0.000322997416021

Figure a2.31. ***Da Eh*** **Mb O1**

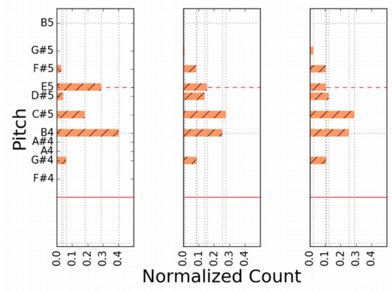

Figure a2.32. ***Da Eh*** **Mb O2**

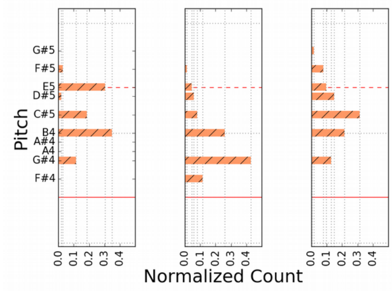

Table a2.31. ***Da Eh*** **Mb O1**

F#4	--	--	0.000293944738389
G#4	0.0599520383693	0.0849802371542	0.105134234764
A4	--	0.000564652738566	0.000587889476778
A#4	--	0.00338791643139	0.00117577895356
B4	0.401918465228	0.2518351214	0.252743484225
C#5	0.182254196643	0.274703557312	0.287184009406
D#5	0.0402877697842	0.138904573687	0.123309817754
E5	0.286810551559	0.154432523998	0.10405643739
F#5	0.0287769784173	0.0841332580463	0.103762492651
G#5	--	0.00705815923207	0.0216049382716
B5	--	--	0.000146972369195

Table a2.32. ***Da Eh*** **Mb O2**

F#4	--	0.114832535885	--
G#4	0.114402451481	0.428229665072	0.129849564529
A4	--	--	0.00316706254949
A#4	--	0.00239234449761	--
B4	0.348314606742	0.258373205742	0.21377672209
C#5	0.185903983657	0.0813397129187	0.315386645553
D#5	0.0183861082737	0.0574162679426	0.147796252309
E5	0.304392236977	0.0454545454545	0.0955397202428
F#5	0.0286006128703	0.011961722488	0.0765373449459
G#5	--	--	0.0179466877804

Figure a2.33. ***Da Eh*** **Mb C**

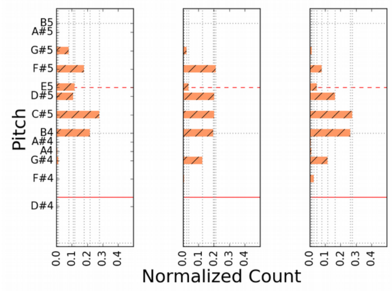

Table a2.33. ***Da Eh*** **Mb C**

D#4	0.00113250283126	--	--
F#4	0.00113250283126	0.00621359223301	0.026626951891
G#4	0.0118912797282	0.125825242718	0.116376327587
A4	0.00566251415629	0.00233009708738	0.00938712880224
A#4	--	--	0.00685982489394
B4	0.218573046433	0.194174757282	0.261997171827
C#5	0.276613816535	0.201165048544	0.275115082589
D#5	0.106738391846	0.202330097087	0.164365014893
E5	0.11919592299	0.033786407767	0.0467551223035
F#5	0.179784824462	0.212815533981	0.0777145951801
G#5	0.079275198188	0.021359223301	0.0140806932034
A#5	--	--	0.000180521707735
B5	--	--	0.000541565123206

Figure a2.34. *Da Xp* Mb

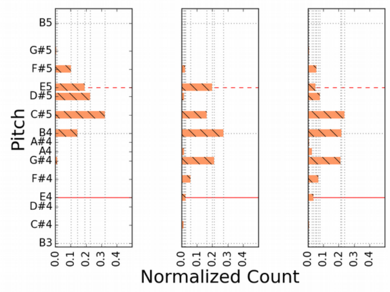

Table a2.34. *Da Xp* Mb

B3	--	0.000523697302959	0.000152625152625
C#4	--	0.0141398271799	0.00641025641026
D#4	--	0.00104739460592	0.00213675213675
E4	--	0.025137470542	0.036858974359
F#4	--	0.0576067033255	0.068605006105
G#4	0.0110921501706	0.211311861744	0.211004273504
A4	--	0.0167583136947	0.0251831501832
A#4	--	--	0.00763125763126
B4	0.143629124005	0.271013354281	0.218253968254
C#5	0.323094425484	0.164179104478	0.23778998779
D#5	0.225255972696	0.0154490704373	0.0776862026862
E5	0.19055745165	0.197172034564	0.0474664224664
F#5	0.101251422071	0.0212097407698	0.055173992674
G#5	0.00511945392491	0.00445142707515	0.00549450549451
B5	--	--	0.000152625152625

Figure a2.35. ***Da Xp*** **Mb O**

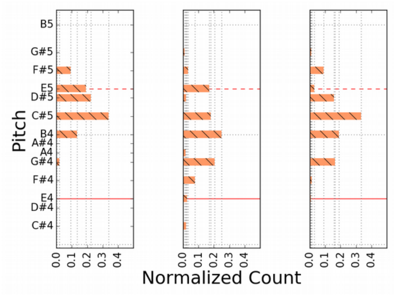

Table a2.35. ***Da Xp*** **Mb O**

C#4	--	0.0189148830264	0.00303183425973
D#4	--	--	0.000336870473303
E4	--	0.0238924838228	0.00741115041267
F#4	--	0.0766550522648	0.0134748189321
G#4	0.017987633502	0.206072672972	0.162540003369
A4	--	0.0159283225485	0.000673740946606
A#4	--	--	0.000673740946606
B4	0.134345137718	0.24987555998	0.19016338218
C#5	0.338392355256	0.179691388751	0.333670203807
D#5	0.223721191681	0.0189148830264	0.158329122452
E5	0.191118605958	0.170731707317	0.0306552130706
F#5	0.0927487352445	0.0308611249378	0.0885969344787
G#5	0.00168634064081	0.00846192135391	0.0101061141991
B5	--	--	0.000336870473303

Figure a2.36. *Da Xp* Mb C

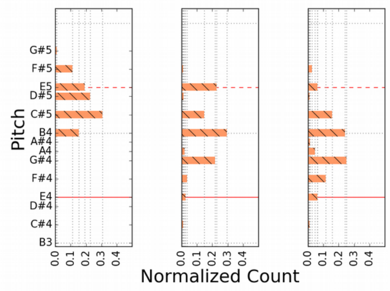

Table a2.36. *Da Xp* Mb C

B3	--	0.00110497237569	0.000279056788056
C#4	--	0.00883977900552	0.00920887400586
D#4	--	0.00220994475138	0.00362773824473
E4	--	0.0265193370166	0.0612529649784
F#4	--	0.0364640883978	0.114273754709
G#4	0.00402993667242	0.217127071823	0.251151109251
A4	--	0.017679558011	0.0454862564532
A#4	--	--	0.0133947258267
B4	0.153137593552	0.294475138122	0.241523650063
C#5	0.307426597582	0.146961325967	0.158364727222
D#5	0.226827864134	0.0116022099448	0.0108832147342
E5	0.189982728843	0.226519337017	0.0613924933724
F#5	0.109959700633	0.0104972375691	0.0274870936236
G#5	0.00863557858377	--	0.00167434072834

Figure a2.37. *Ls Xp* Kb

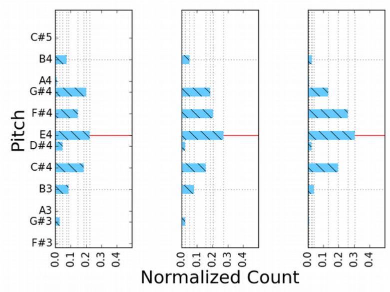

Table a2.37. *Ls Xp* Kb

F#3	--	--	0.00227479526843
G#3	0.0282442748092	0.0227979274611	0.00727934485896
A3	--	--	0.00227479526843
B3	0.0847328244275	0.0791018998273	0.0377616014559
C#4	0.185114503817	0.156476683938	0.196542311192
D#4	0.0458015267176	0.0224525043178	0.0232029117379
E4	0.223282442748	0.272884283247	0.305277525023
F#4	0.147709923664	0.203799654577	0.261146496815
G#4	0.200763358779	0.184455958549	0.130573248408
A4	0.00916030534351	0.00414507772021	0.00727934485896
B4	0.0721374045802	0.0497409326425	0.024567788899
C#5	0.0030534351145	0.0027633851468	0.00090991810737
E5	--	0.0013816925734	0.00090991810737

Figure a2.38. *Ls Xp* Kb O

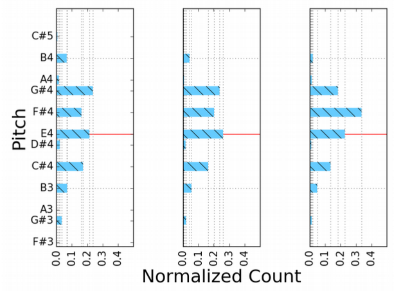

Table a2.38. *Ls Xp* Kb O

F#3	--	--	0.00414593698176
G#3	0.0335570469799	0.0186046511628	0.0132669983416
A3	--	--	0.00414593698176
B3	0.0711409395973	0.0527131782946	0.0497512437811
C#4	0.172483221477	0.162015503876	0.135157545605
D#4	0.0214765100671	0.015503875969	0.00995024875622
E4	0.214093959732	0.260465116279	0.228855721393
F#4	0.163087248322	0.200775193798	0.335820895522
G#4	0.236241610738	0.237209302326	0.18407960199
A4	0.0161073825503	0.0062015503876	0.0132669983416
B4	0.0664429530201	0.0403100775194	0.0182421227197
C#5	0.00536912751678	0.0031007751938	0.0016583747927
E5	--	0.0031007751938	0.0016583747927

Figure a2.39. *Ls Xp* Kb C

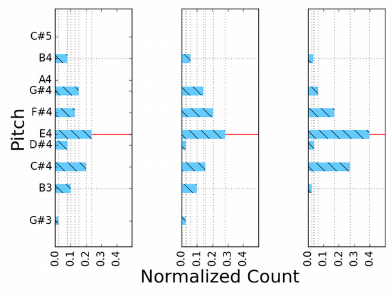

Table a2.39. *Ls Xp* Kb C

G#3	0.0212389380531	0.0261682242991	--
B3	0.102654867257	0.10031152648	0.023185483871
C#4	0.201769911504	0.152024922118	0.271169354839
D#4	0.0778761061947	0.0280373831776	0.039314516129
E4	0.235398230088	0.282866043614	0.398185483871
F#4	0.127433628319	0.206230529595	0.170362903226
G#4	0.153982300885	0.142056074766	0.0655241935484
A4	--	0.00249221183801	--
B4	0.0796460176991	0.0573208722741	0.0322580645161
C#5	--	0.00249221183801	--

Figure a2.40. *Da Xp* Kb

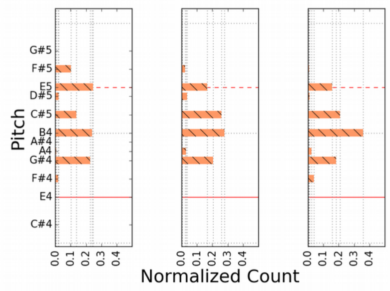

Table a2.40. *Da Xp* Kb

C#4	--	--	0.00236434566734
E4	--	0.00129743756082	0.00425582220121
F#4	0.0176671351134	0.00259487512163	0.0401938763447
G#4	0.228066653282	0.204022056439	0.184064310202
A4	0.00602288697049	0.0272461887772	0.0226977184064
A#4	--	0.00259487512163	0.00189147653387
B4	0.239309375627	0.277002919235	0.359853410569
C#5	0.135715719735	0.258838793383	0.210072112543
D#5	0.0224854446898	0.0363282517029	0.0105213382196
E5	0.2449307368	0.166072007785	0.157938290578
F#5	0.102188315599	0.0233538760947	0.00614729873508
G#5	0.00361373218229	0.000648718780409	--

Figure a2.41. ***Da Xp*** **Kb O**

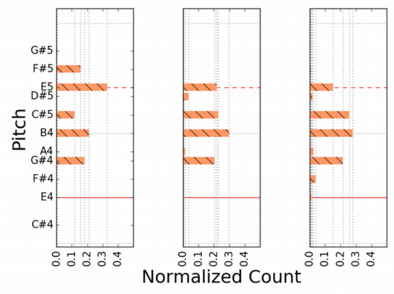

Figure a2.42. ***Da Xp*** **Kb C**

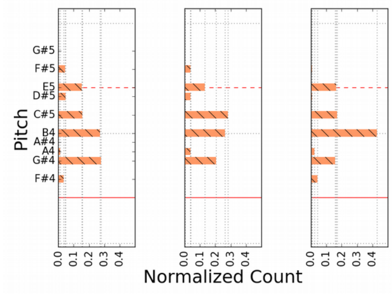

Table a2.41. ***Da Xp*** **Kb O**

C#4	--	--	0.00509554140127
E4	--	0.0032310177706	0.00917197452229
F#4	0.00153315446531	0.0032310177706	0.0397452229299
G#4	0.182445381372	0.20436187399	0.214012738854
A4	--	0.0113085621971	0.0234394904459
B4	0.210042161748	0.29886914378	0.27821656051
C#5	0.118052893829	0.226978998384	0.257834394904
D#5	--	0.0355411954766	0.0155414012739
E5	0.328095055577	0.21647819063	0.149808917197
F#5	0.155231889613	--	0.00713375796178
G#5	0.00459946339594	--	--

Table a2.42. ***Da Xp*** **Kb C**

F#4	0.035413153457	0.00216802168022	0.0405822673136
G#4	0.278246205734	0.20379403794	0.158138509043
A4	0.0126475548061	0.0379403794038	0.0220555800618
A#4	--	0.00433604336043	0.00352889280988
B4	0.27150084317	0.262330623306	0.430524922805
C#5	0.155143338954	0.280216802168	0.168725187472
D#5	0.0472175379427	0.0368563685637	0.00617556241729
E5	0.153456998314	0.132249322493	0.164975738862
F#5	0.043844856661	0.0390243902439	0.00529333921482
G#5	0.00252951096121	0.00108401084011	--

a3. Non directed interval histograms

Figure a3.1. *Ls*

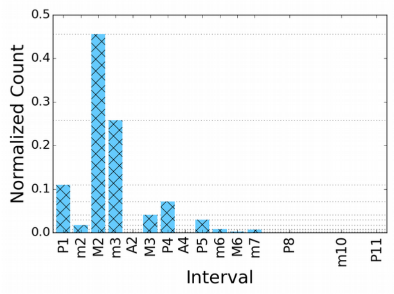

Figure a3.2. *Da*

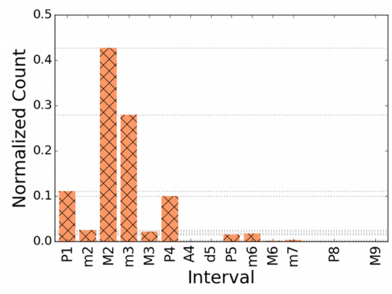

Table a3.1. *Ls*

P1	0.10960105217
m2	0.0171854449803
M2	0.455501972819
m3	0.258044717229
A2	0.0000876808417361
M3	0.0413853572994
P4	0.0708461201228
A4	0.0000876808417361
P5	0.0292854011399
m6	0.00789127575625
M6	0.0021920210434
m7	0.00736519070583
P8	0.000263042525208
m10	0.000175361683472
P11	0.0000876808417361

Table a3.2. *Da*

P1	0.110684668631
m2	0.0251524912617
M2	0.427455280652
m3	0.279350284422
M3	0.0210403673497
P4	0.100198752656
A4	0.000137070797067
d5	0.0002056061956
P5	0.0151463230759
m6	0.0169967788363
M6	0.000548283188267
m7	0.00294702213693
P8	0.0000685353985333
M9	0.0000685353985333

Figure a3.3. *Eh*

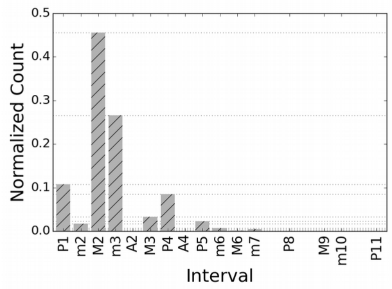

Figure a3.4. *Xp*

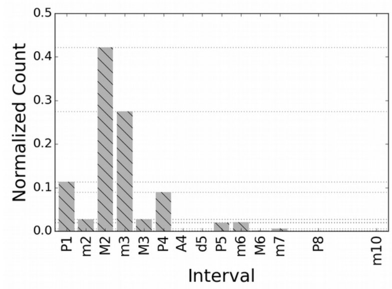

Table a3.3. *Eh*

P1	0.107570011669
m2	0.0166277712952
M2	0.456023920653
m3	0.265533838973
A2	0.0000729288214702
M3	0.0327450408401
P4	0.0854725787631
A4	0.0000729288214702
P5	0.023264294049
m6	0.00670945157526
M6	0.00123978996499
m7	0.00422987164527
P8	0.000218786464411
M9	0.0000729288214702
m10	0.0000729288214702
P11	0.0000729288214702

Table a3.4. *Xp*

P1	0.113155323999
m2	0.0272712471508
M2	0.42160534028
m3	0.274991859329
M3	0.0268642136112
P4	0.0893845652882
A4	0.000162813415825
d5	0.000244220123738
P5	0.0192119830674
m6	0.0200260501465
M6	0.0013025073266
m7	0.00561706284598
P8	0.0000814067079127
m10	0.0000814067079127

Figure a3.5. ***Ls Eh***

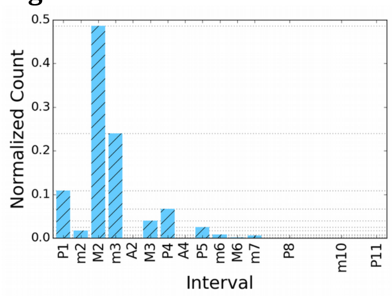

Figure a3.6. ***Ls Xp***

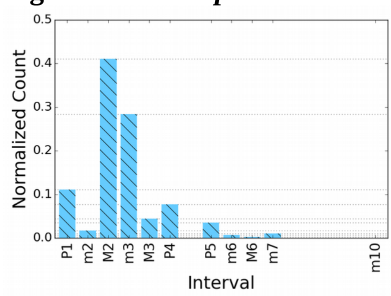

Table a3.5. ***Ls Eh***

P1	0.10835413302
m2	0.0174717368962
M2	0.486125385406
m3	0.240346498312
A2	0.000146821318455
M3	0.0393481133461
P4	0.0665100572603
A4	0.000146821318455
P5	0.0251064454559
m6	0.0082219938335
M6	0.00176185582147
m7	0.00572603141976
P8	0.000440463955366
m10	0.000146821318455
P11	0.000146821318455

Table a3.6. ***Ls Xp***

P1	0.111449717022
m2	0.016760992599
M2	0.410100130605
m3	0.284283848498
M3	0.044405746626
P4	0.0772747061384
P5	0.0354810622551
m6	0.00740095777101
M6	0.00282977797127
m7	0.00979538528515
m10	0.000217675228559

Figure a3.7. ***Da Eh***

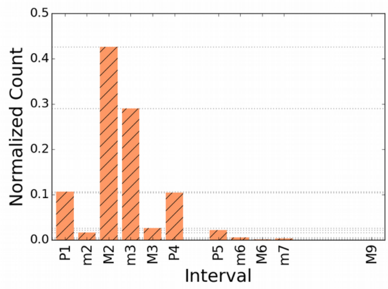

Figure a3.8. ***Da Xp***

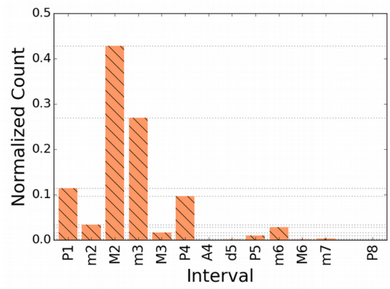

Table a3.7. ***Da Eh***

P1	0.106796116505
m2	0.015794812346
M2	0.426315026808
m3	0.290392696711
M3	0.0262280828865
P4	0.10418779887
P5	0.0214461672221
m6	0.00521663527025
M6	0.000724532676424
m7	0.00275322417041
M9	0.000144906535285

Table a3.8. ***Da Xp***

P1	0.114174252276
m2	0.0335500650195
M2	0.428478543563
m3	0.26944083225
M3	0.0163849154746
P4	0.0966189856957
A4	0.000260078023407
d5	0.000390117035111
P5	0.00949284785436
m6	0.0275682704811
M6	0.000390117035111
m7	0.00312093628088
P8	0.000130039011704

Figure a3.9. *Ls Eh* Yb

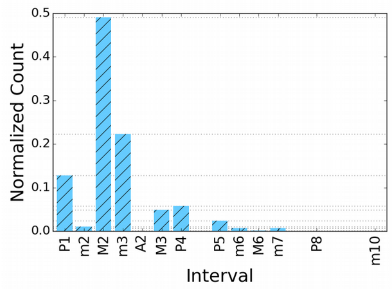

Figure a3.10. *Ls Xp* Yb

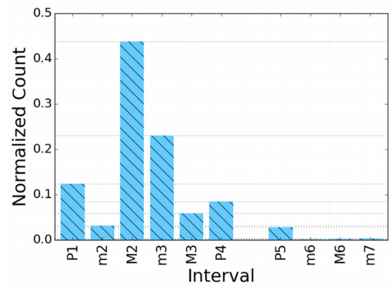

Table a3.9. *Ls Eh* Yb

P1	0.128313891835
m2	0.0106044538706
M2	0.49098621421
m3	0.222693531283
A2	0.000353481795688
M3	0.0491339696006
P4	0.0579710144928
P5	0.0240367621068
m6	0.00671615411806
M6	0.00141392718275
m7	0.00706963591375
P8	0.000353481795688
m10	0.000353481795688

Table a3.10. *Ls Xp* Yb

P1	0.123314065511
m2	0.0317919075145
M2	0.437379576108
m3	0.230250481696
M3	0.0587668593449
P4	0.0847784200385
P5	0.0279383429672
m6	0.000963391136802
M6	0.0019267822736
m7	0.0028901734104

Figure a3.11. ***Da Eh*** **Yb**

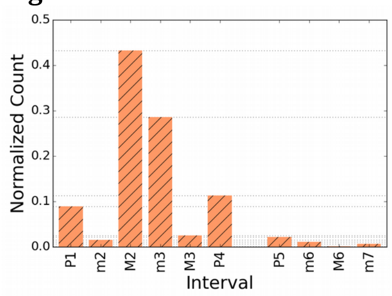

Figure a3.12. ***Da Xp*** **Yb**

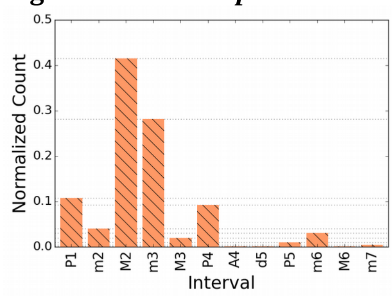

Table a3.11. ***Da Eh*** **Yb**

P1	0.0891758917589
m2	0.0147601476015
M2	0.432964329643
m3	0.285362853629
M3	0.0252152521525
P4	0.113161131611
P5	0.0215252152522
m6	0.0110701107011
M6	0.000615006150062
m7	0.00615006150062

Table a3.12. ***Da Xp*** **Yb**

P1	0.106980586534
m2	0.0396530359356
M2	0.41511771995
m3	0.281288723668
M3	0.0194134655101
P4	0.0921106980587
A4	0.000413052457662
d5	0.000413052457662
P5	0.00950020652623
m6	0.0301528294093
M6	0.000413052457662
m7	0.00454357703428

Figure a3.13. *Ls Eh* Mb

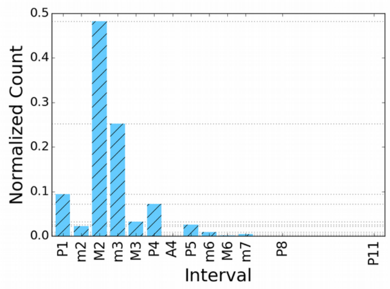

Figure a3.14. *Ls Xp* Mb

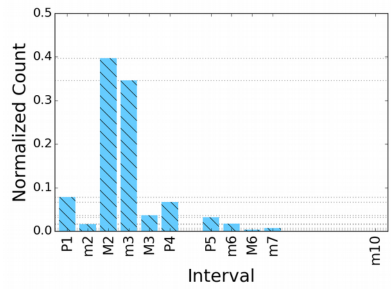

Table a3.13. *Ls Eh* Mb

P1	0.0941737820191
m2	0.0223505775992
M2	0.482672024108
m3	0.252887995982
M3	0.0323957810146
P4	0.072576594676
A4	0.000251130085384
P5	0.0258663987946
m6	0.00929181315922
M6	0.00200904068307
m7	0.0047714716223
P8	0.000502260170768
P11	0.000251130085384

Table a3.14. *Ls Xp* Mb

P1	0.0778331257783
m2	0.0155666251557
M2	0.397260273973
m3	0.345579078456
M3	0.0361145703611
P4	0.0672478206725
P5	0.0323785803238
m6	0.0168119551681
M6	0.00373599003736
m7	0.00684931506849
m10	0.000622665006227

Figure a3.15. ***Da Eh*** **Mb**

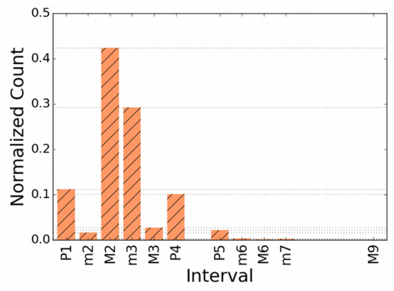

Figure a3.16. ***Da Xp*** **Mb**

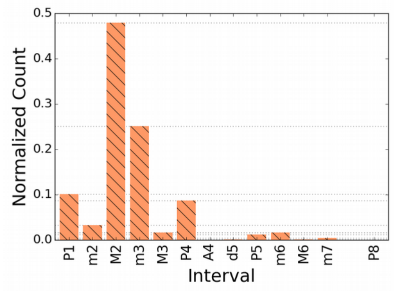

Table a3.15. ***Da Eh*** **Mb**

P1	0.112227488152
m2	0.0161137440758
M2	0.424265402844
m3	0.291943127962
M3	0.0265402843602
P4	0.101421800948
P5	0.0214218009479
m6	0.00341232227488
M6	0.000758293838863
m7	0.00170616113744
M9	0.000189573459716

Table a3.16. ***Da Xp*** **Mb**

P1	0.101120193763
m2	0.0320920375416
M2	0.479564032698
m3	0.250378443839
M3	0.0160460187708
P4	0.0865879503482
A4	0.000302755071147
d5	0.000605510142295
P5	0.0121102028459
m6	0.016348773842
M6	0.000605510142295
m7	0.00393581592492
P8	0.000302755071147

Figure a3.17. *Ls Xp* Kb

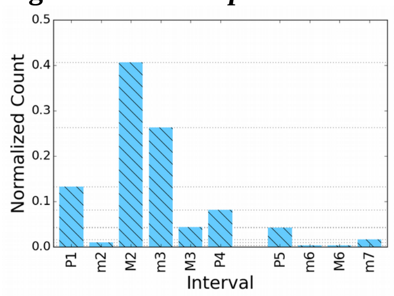

Figure a3.18. *Da Xp* Kb

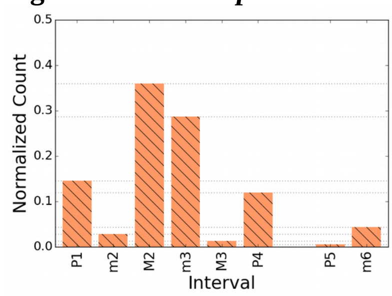

Table a3.17. *Ls Xp* Kb

P1	0.132820512821
m2	0.00974358974359
M2	0.406153846154
m3	0.262564102564
M3	0.0435897435897
P4	0.0815384615385
P5	0.0420512820513
m6	0.00307692307692
M6	0.0025641025641
m7	0.0158974358974

Table a3.18. *Da Xp* Kb

P1	0.14496439471
m2	0.028484231943
M2	0.359104781282
m3	0.286876907426
M3	0.0132248219736
P4	0.119023397762
P5	0.00508646998983
m6	0.0432349949135

a4. Directed interval histograms

Figure a4.1. ***Ls***

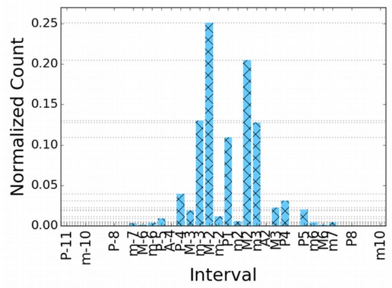

Table a4.1. ***Ls***

P-11	0.0000876808417361
m-10	0.0000876808417361
P-8	0.000175361683472
m-7	0.00298114861903
M-6	0.00122753178431
m-6	0.00385795703639
P-5	0.00894344585708
A-4	0.0000876808417361
P-4	0.039544059623
M-3	0.0187637001315
m-3	0.130206049978
M-2	0.250854888207
m-2	0.0115738711092
P1	0.10960105217
m2	0.00561157387111
M2	0.204647084612
m3	0.127838667251
A2	0.0000876808417361
M3	0.0226216571679
P4	0.0313020604998
P5	0.0203419552828
m6	0.00403331871986
M6	0.000964489259097
m7	0.0043840420868
P8	0.0000876808417361
m10	0.0000876808417361

Figure a4.2. ***Da***

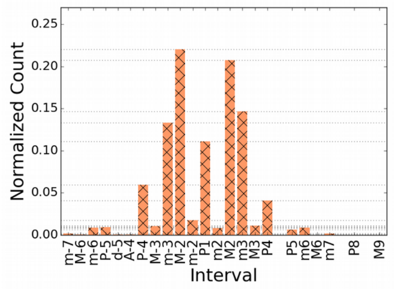

Table a4.2. ***Da***

m-7	0.00130217257213
M-6	0.000479747789733
m-6	0.00829278322253
P-5	0.0090466726064
d-5	0.0002056061956
A-4	0.000137070797067
P-4	0.0595572613255
M-3	0.01028030978
m-3	0.132890137756
M-2	0.220135700089
m-2	0.0170653142348
P1	0.110684668631
m2	0.00808717702693
M2	0.207319580563
m3	0.146460146666
M3	0.0107600575697
P4	0.0406414913303
P5	0.00609965046947
m6	0.00870399561373
M6	0.0000685353985333
m7	0.0016448495648
P8	0.0000685353985333
M9	0.0000685353985333

Figure a4.3. ***Eh***

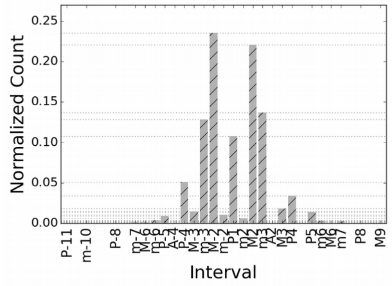

Table a4.3. ***Eh***

P-11	0.0000729288214702
m-10	0.0000729288214702
P-8	0.00014585764294
m-7	0.0019690781797
M-6	0.000948074679113
m-6	0.00364644107351
P-5	0.00904317386231
A-4	0.00007.29288214702
P-4	0.0511960326721
M-3	0.0148045507585
m-3	0.128427654609
M-2	0.235487164527
m-2	0.0104288214702
P1	0.107570011669
m2	0.00619894982497
M2	0.220536756126
m3	0.137106184364
A2	0.00007.29288214702
M3	0.0179404900817
P4	0.034276546091
P5	0.0142211201867
m6	0.00306301050175
M6	0.000291715285881
m7	0.00226079346558
P8	0.0000729288214702
M9	0.0000729288214702

Figure a4.4. ***Xp***

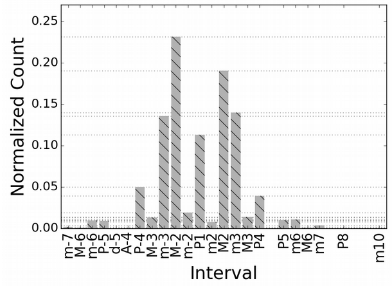

Table a4.4. ***Xp***

m-7	0.00211657440573
M-6	0.000651253663302
m-6	0.00936177140996
P-5	0.0089547378704
d-5	0.000244220123738
A-4	0.000162813415825
P-4	0.0503093454901
M-3	0.0131064799739
m-3	0.135379355259
M-2	0.231520677304
m-2	0.0193747964832
P1	0.113155323999
m2	0.00789645066754
M2	0.190084662976
m3	0.13961250407
M3	0.0137577336373
P4	0.0390752197981
P5	0.010257245197
m6	0.0106642787366
M6	0.000651253663302
m7	0.00350048844025
P8	0.00008.14067079127
m10	0.0000814067079127

Figure a4.5. ***Ls Eh***

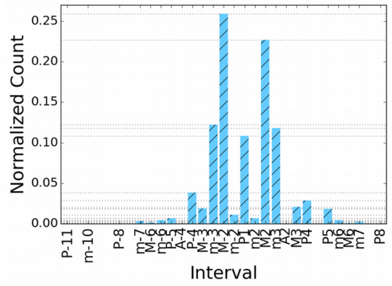

Table a4.5. ***Ls Eh***

P-11	0.000146821318455
m-10	0.000146821318455
P-8	0.000293642636911
m-7	0.00308324768756
M-6	0.00117457054764
m-6	0.00411099691675
P-5	0.00660695933049
A-4	0.000146821318455
P-4	0.03802672148
M-3	0.0186463074438
m-3	0.122155336955
M-2	0.259139627074
m-2	0.0108647775657
P1	0.10835413302
m2	0.00660695933049
M2	0.226985758332
m3	0.118191161357
A2	0.000146821318455
M3	0.0207018059022
P4	0.0284833357804
P5	0.0184994861254
m6	0.00411099691675
M6	0.000587285273822
m7	0.0026427837322
P8	0.000146821318455

Figure a4.6. *Ls Xp*

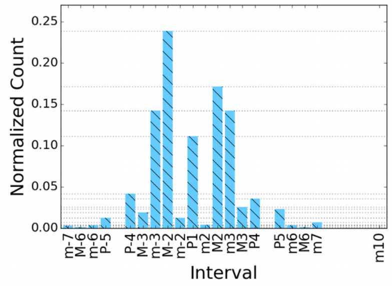

Table a4.6. *Ls Xp*

m-7	0.00282977797127
M-6	0.00130605137135
m-6	0.00348280365694
P-5	0.0124074880279
P-4	0.0417936438833
M-3	0.0189377448846
m-3	0.142141924249
M-2	0.238572050501
m-2	0.0126251632564
P1	0.111449717022
m2	0.00413582934262
M2	0.171528080104
m3	0.142141924249
M3	0.0254680017414
P4	0.0354810622551
P5	0.0230735742273
m6	0.00391815411406
M6	0.00152372659991
m7	0.00696560731389
m10	0.000217675228559

Figure a4.7. ***Da Eh***

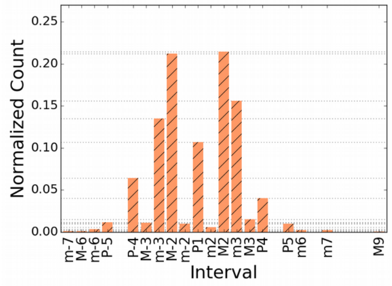

Figure a4.8. ***Da Xp***

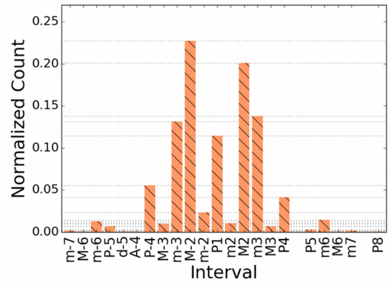

Table a4.7. ***Da Eh***

m-7	0.000869439211708
M-6	0.000724532676424
m-6	0.00318794377626
P-5	0.0114476162875
P-4	0.0641935951311
M-3	0.0110128966816
m-3	0.13461817128
M-2	0.212143167657
m-2	0.00999855093465
P1	0.106796116505
m2	0.00579626141139
M2	0.214171859151
m3	0.155774525431
M3	0.0152151862049
P4	0.0399942037386
P5	0.00999855093465
m6	0.00202869149399
m7	0.0018837849587
M9	0.000144906535285

Table a4.8. ***Da Xp***

m-7	0.00169050715215
M-6	0.000260078023407
m-6	0.0128738621586
P-5	0.00689206762029
d-5	0.000390117035111
A-4	0.000260078023407
P-4	0.0553966189857
M-3	0.00962288686606
m-3	0.131339401821
M-2	0.227308192458
m-2	0.0234070221066
P1	0.114174252276
m2	0.0101430429129
M2	0.201170351105
m3	0.138101430429
M3	0.00676202860858
P4	0.04122236671
P5	0.00260078023407
m6	0.0146944083225
M6	0.000130039011704
m7	0.00143042912874
P8	0.000130039011704

Figure a4.9. ***Ls Eh*** **Yb**

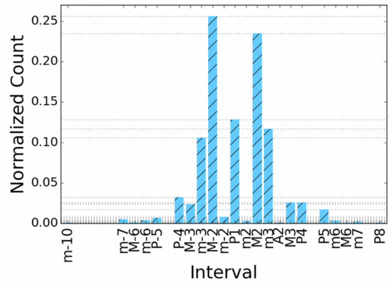

Figure a4.10. ***Ls Xp*** **Yb**

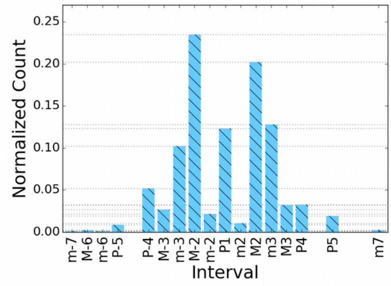

Table a4.9. ***Ls Eh*** **Yb**

m-10	0.000353481795688
m-7	0.00494874513963
M-6	0.00106044538706
m-6	0.00388829975256
P-5	0.00671615411806
P-4	0.0321668434076
M-3	0.0236832803111
m-3	0.106044538706
M-2	0.256274301873
m-2	0.00813008130081
P1	0.128313891835
m2	0.00247437256981
M2	0.234711912337
m3	0.116648992577
A2	0.000353481795688
M3	0.0254506892895
P4	0.0258041710852
P5	0.0173206079887
m6	0.0028278543655
M6	0.000353481795688
m7	0.00212089077413
P8	0.000353481795688

Table a4.10. ***Ls Xp*** **Yb**

m-7	0.000963391136802
M-6	0.0019267822736
m-6	0.000963391136802
P-5	0.00867052023121
P-4	0.0520231213873
M-3	0.0269749518304
m-3	0.102119460501
M-2	0.23506743738
m-2	0.0211946050096
P1	0.123314065511
m2	0.0105973025048
M2	0.202312138728
m3	0.128131021195
M3	0.0317919075145
P4	0.0327552986513
P5	0.019267822736
m7	0.0019267822736

Figure a4.11. ***Da Eh*** **Yb**

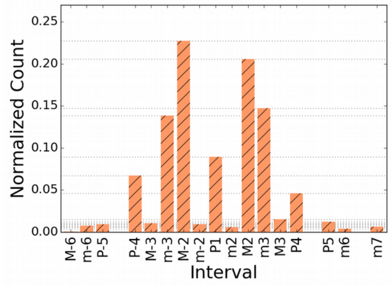

Figure a4.12. ***Da Xp*** **Yb**

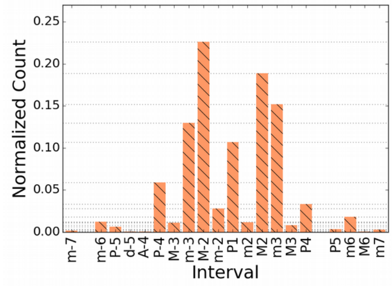

Table a4.11. ***Da Eh*** **Yb**

M-6	0.000615006150062
m-6	0.00738007380074
P-5	0.00922509225092
P-4	0.0670356703567
M-3	0.010455104551
m-3	0.138376383764
M-2	0.227552275523
m-2	0.00922509225092
P1	0.0891758917589
m2	0.00553505535055
M2	0.205412054121
m3	0.146986469865
M3	0.0147601476015
P4	0.0461254612546
P5	0.0123001230012
m6	0.00369003690037
m7	0.00615006150062

Table a4.12. ***Da Xp*** **Yb**

m-7	0.00165220983065
m-6	0.0119785212722
P-5	0.00619578686493
d-5	0.000413052457662
A-4	0.000413052457662
P-4	0.0590665014457
M-3	0.0111524163569
m-3	0.129698471706
M-2	0.226352746799
m-2	0.028087567121
P1	0.106980586534
m2	0.0115654688145
M2	0.188764973152
m3	0.151590251962
M3	0.00826104915324
P4	0.033044196613
P5	0.0033044196613
m6	0.0181743081371
M6	0.000413052457662
m7	0.00289136720363

Figure a4.13. ***Ls Eh*** **Mb**

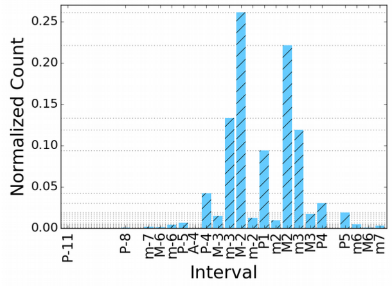

Figure a4.14. ***Ls Xp*** **Mb**

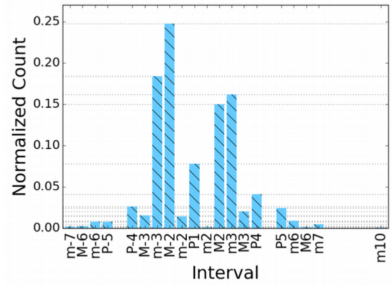

Table a4.13. ***Ls Eh*** **Mb**

P-11	0.000251130085384
P-8	0.000502260170768
m-7	0.00175791059769
M-6	0.00125565042692
m-6	0.00426921145153
P-5	0.00652938221999
A-4	0.000251130085384
P-4	0.0421898543446
M-3	0.0150678051231
m-3	0.133601205424
M-2	0.2611752888
m-2	0.0128076343546
P1	0.0941737820191
m2	0.0095429432446
M2	0.221496735309
m3	0.119286790558
M3	0.0173279758915
P4	0.0303867403315
P5	0.0193370165746
m6	0.00502260170768
M6	0.000753390256153
m7	0.00301356102461

Table a4.14. ***Ls Xp*** **Mb**

m-7	0.00186799501868
M-6	0.00249066002491
m-6	0.00809464508095
P-5	0.00809464508095
P-4	0.0261519302615
M-3	0.0155666251557
m-3	0.183686176837
M-2	0.247198007472
m-2	0.0143212951432
P1	0.0778331257783
m2	0.00124533001245
M2	0.150062266501
m3	0.161892901619
M3	0.0205479452055
P4	0.041095890411
P5	0.0242839352428
m6	0.00871731008717
M6	0.00124533001245
m7	0.00498132004981
m10	0.000622665006227

Figure a4.15. ***Da Eh*** **Mb**

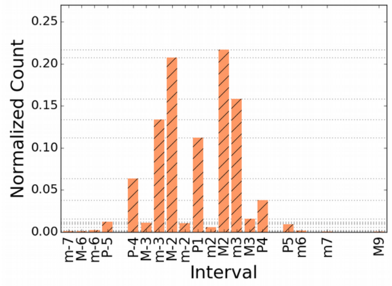

Figure a4.16. ***Da Xp*** **Mb**

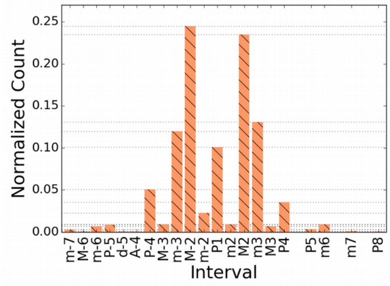

Table a4.15. ***Da Eh*** **Mb**

m-7	0.00113744075829
M-6	0.000758293838863
m-6	0.00189573459716
P-5	0.0121327014218
P-4	0.063317535545
M-3	0.0111848341232
m-3	0.13345971564
M-2	0.207393364929
m-2	0.0102369668246
P1	0.112227488152
m2	0.00587677725118
M2	0.216872037915
m3	0.158483412322
M3	0.015355450237
P4	0.0381042654028
P5	0.00928909952607
m6	0.00151658767773
m7	0.000568720379147
M9	0.000189573459716

Table a4.16. ***Da Xp*** **Mb**

m-7	0.00272479564033
M-6	0.000605510142295
m-6	0.00696336663639
P-5	0.00877989706328
d-5	0.000605510142295
A-4	0.000302755071147
P-4	0.0508628519528
M-3	0.00908265213442
m-3	0.119588253103
M-2	0.244928852558
m-2	0.0227066303361
P1	0.101120193763
m2	0.00938540720557
M2	0.234635180139
m3	0.130790190736
M3	0.00696336663639
P4	0.0357250983954
P5	0.00333030578262
m6	0.00938540720557
m7	0.00121102028459
P8	0.000302755071147

Figure a4.17. ***Ls Xp*** **Kb**

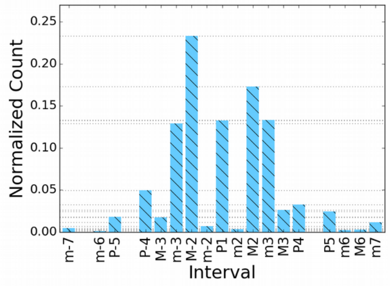

Figure a4.18. ***Da Xp*** **Kb**

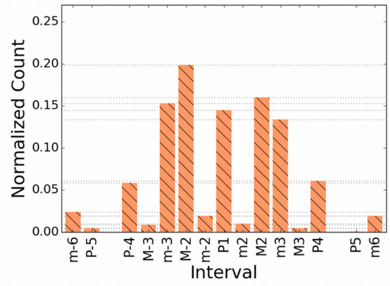

Table a4.17. ***Ls Xp*** **Kb**

m-7	0.00461538461538
m-6	0.00102564102564
P-5	0.0179487179487
P-4	0.0492307692308
M-3	0.0174358974359
m-3	0.129230769231
M-2	0.233333333333
m-2	0.00666666666667
P1	0.132820512821
m2	0.00307692307692
M2	0.172820512821
m3	0.133333333333
M3	0.0261538461538
P4	0.0323076923077
P5	0.0241025641026
m6	0.00205128205128
M6	0.0025641025641
m7	0.0112820512821

Table a4.18. ***Da Xp*** **Kb**

m-6	0.0239064089522
P-5	0.00457782299084
P-4	0.058494404883
M-3	0.00864699898271
m-3	0.153102746694
M-2	0.198880976602
m-2	0.0188199389624
P1	0.14496439471
m2	0.00966429298067
M2	0.16022380468
m3	0.133774160732
M3	0.00457782299084
P4	0.0605289928789
P5	0.000508646998983
m6	0.0193285859613

a5. Cadential notes

Figure a5.1. *Ls Eh*

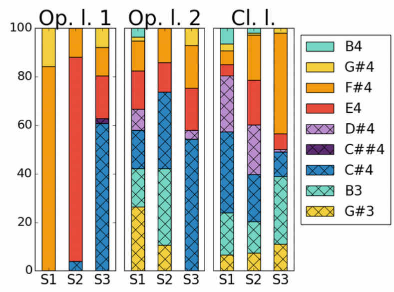

Table a5.1. *Ls Eh*

	Opening line 1			Opening line 2			Closing line		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
G#3	0.0	0.0	0.0	26.31	10.53	0.0	6.48	7.41	11.11
B3	0.0	0.0	0.0	15.79	31.58	0.0	17.59	12.96	27.78
C#4	0.0	3.92	60.78	15.79	31.58	54.39	33.33	19.44	10.19
C##4	0.0	0.0	1.96	0.0	0.0	0.0	0.0	0.0	0.0
D#4	0.0	0.0	0.0	8.77	0.0	3.51	23.15	20.37	0.93
E4	0.0	84.31	17.65	15.79	12.28	17.54	4.63	18.52	6.48
F#4	84.31	11.76	11.76	12.28	14.04	17.54	5.56	18.52	41.67
G#4	15.69	0.0	7.849	1.759	0.0	7.02	2.78	0.93	1.852
B4	0.0	0.0	0.0	3.51	0.0	0.0	6.48	1.85	0.0

Figure a5.2. *Ls Xp*

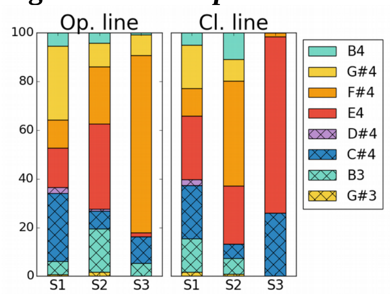

Table a5.2. *Ls Xp*

	Opening line			Closing line		
	S1	S2	S3	S1	S2	S3
G#3	0.78	1.63	0.0	1.63	0.83	0.0
B3	5.43	17.89	5.43	13.82	6.61	0.0
C#4	27.91	7.32	10.85	21.95	5.79	26.02
D#4	2.33	0.81	0.0	2.44	0.0	0.0
E4	16.28	34.96	1.55	26.02	23.97	72.36
F#4	11.63	23.58	72.87	11.38	42.98	1.63
G#4	30.23	9.76	8.53	17.89	9.09	0.0
B4	5.43	4.07	0.78	4.88	10.74	0.0

Figure a5.3. ***Da Eh***

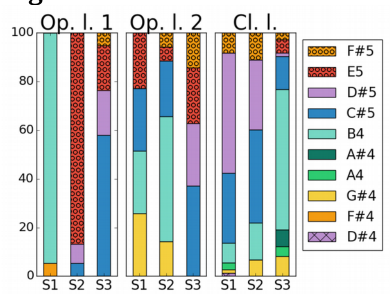

Table a5.3. ***Da Eh***

	Opening line 1			Opening line 2			Closing line		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
D#4	0.0	0.0	0.0	0.0	0.0	0.0	1.37	0.0	0.0
F#4	5.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G#4	0.0	0.0	0.0	25.71	14.29	0.0	1.37	6.85	8.22
A4	0.0	0.0	0.0	0.0	0.0	0.0	2.74	0.0	4.11
A#4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.85
B4	94.74	0.0	0.0	25.71	51.43	0.0	8.22	15.07	57.53
C#5	0.0	5.26	57.89	25.71	22.86	37.14	28.77	38.36	13.7
D#5	0.0	7.89	18.42	0.0	0.0	25.71	49.32	28.77	1.37
E5	0.0	86.84	18.42	22.86	5.71	22.86	0.0	0.0	5.48
F#5	0.0	0.0	5.26	0.0	5.71	14.29	8.22	10.96	2.74

Figure a5.4. *Da Xp*

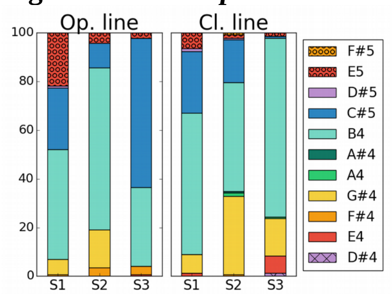

Table a5.4. *Da Xp*

	Opening line			Closing line		
	S1	S2	S3	S1	S2	S3
D#4	0.0	0.0	0.0	0.0	0.0	1.4
E4	0.0	0.0	0.71	1.4	0.0	6.99
F#4	0.7	3.55	3.52	0.0	0.7	0.0
G#4	6.34	15.6	0.0	7.69	32.17	15.38
A4	0.0	0.0	0.0	0.0	1.4	0.7
A#4	0.0	0.0	0.0	0.0	0.7	0.0
B4	45.07	66.67	32.39	58.04	44.76	73.43
C#5	25.35	9.93	61.27	25.17	17.48	0.7
D#5	0.7	0.0	0.0	1.4	0.7	0.0
E5	21.83	4.26	2.11	6.29	1.4	1.4
F#5	0.0	0.0	0.0	0.0	0.7	0.0

Figure a5.5. *Ls Eh* Yb

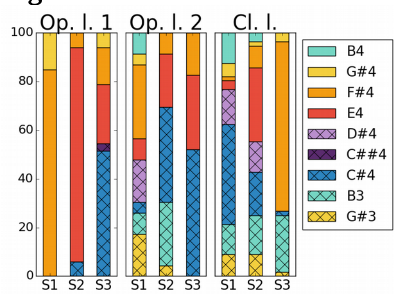

Table a5.5. *Ls Eh* Yb

	Opening line 1			Opening line 2			Closing line		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
G#3	0.0	0.0	0.0	17.39	4.35	0.0	8.93	8.93	1.79
B3	0.0	0.0	0.0	8.7	26.09	0.0	12.5	16.07	23.21
C#4	0.0	6.06	51.52	4.35	39.13	52.17	41.07	17.86	1.79
C##4	0.0	0.0	3.03	0.0	0.0	0.0	0.0	0.0	0.0
D#4	0.0	0.0	0.0	17.39	0.0	0.0	14.29	12.5	0.0
E4	0.0	87.88	24.24	8.7	21.74	30.43	3.57	30.36	0.0
F#4	84.85	6.06	15.15	30.43	8.7	17.39	1.79	8.93	69.64
G#4	15.15	0.0	6.06	4.35	0.0	0.0	5.36	1.79	3.57
B4	0.0	0.0	0.0	8.7	0.0	0.0	12.5	3.57	0.0

Figure a5.6. *Ls Xp* Yb

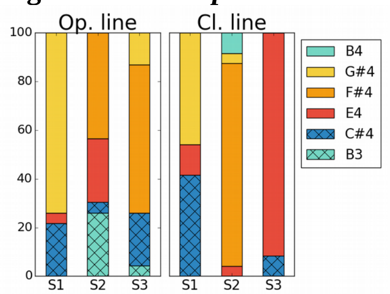

Table a5.6. *Ls Xp* Yb

	Opening line			Closing line		
	S1	S2	S3	S1	S2	S3
B3	0.0	26.09	4.35	0.0	0.0	0.0
C#4	21.74	4.35	21.74	41.667	0.0	8.33
E4	4.35	26.09	0.0	12.5	4.17	91.67
F#4	0.0	43.49	60.87	0.0	83.33	0.0
G#4	73.91	0.0	13.04	45.83	4.17	0.0
B4	0.0	0.0	0.0	0.0	8.33	0.0

Figure a5.7. *Da Eh* Yb

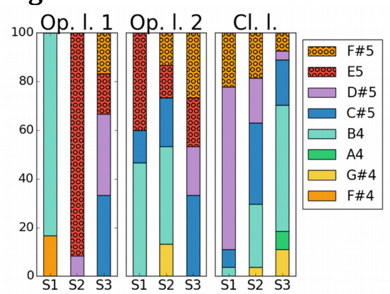

Table a5.7. *Da Eh* Yb

	Opening line 1			Opening line 2			Closing line		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
F#4	16.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G#4	0.0	0.0	0.0	0.0	13.33	0.0	0.0	3.7	11.11
A4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.41
B4	83.33	0.0	0.0	46.67	40.0	0.0	3.7	25.93	51.85
C#5	0.0	0.0	33.33	13.33	20.0	33.33	7.41	33.33	18.52
D#5	0.0	8.33	33.33	0.0	0.0	20.0	66.67	18.52	3.7
E5	0.0	91.67	16.67	40.0	13.33	20.0	0.0	0.0	0.0
F#5	0.0	0.0	16.67	0.0	13.33	26.67	22.22	18.52	7.41

Figure a5.8. *Da Xp* Yb

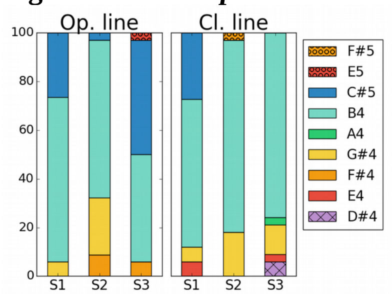

Table a5.8. *Da Xp* Yb

	Opening line			Closing line		
	S1	S2	S3	S1	S2	S3
D#4	0.0	0.0	0.0	0.0	0.0	6.06
E4	0.0	0.0	0.0	6.06	0.0	3.03
F#4	0.0	8.82	5.88	0.0	0.0	0.0
G#4	5.88	23.53	0.0	6.06	18.18	12.12
A4	0.0	0.0	0.0	0.0	0.0	3.03
B4	67.65	64.71	44.12	60.61	78.79	75.76
C#5	26.47	2.94	47.06	27.27	0.0	0.0
E5	0.0	0.0	2.94	0.0	0.0	0.0
F#5	0.0	0.0	0.0	0.0	3.03	0.0

Figure a5.9. *Ls Eh* Mb

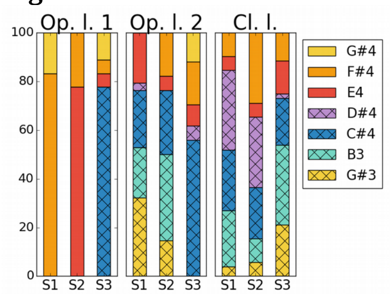

Table a5.9. *Ls Eh* Mb

	Opening line 1			Opening line 2			Closing line		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
G#3	0.0	0.0	0.0	32.35	14.71	0.0	3.85	5.77	21.15
B3	0.0	0.0	0.0	20.59	35.29	0.0	23.08	9.62	32.69
C#4	0.0	0.0	77.778	23.53	26.47	55.88	25.0	21.15	19.23
D#4	0.0	0.0	0.0	2.94	0.0	5.88	32.69	28.85	1.92
E4	0.0	77.78	5.56	20.59	5.88	8.82	5.77	5.77	13.46
F#4	83.33	22.22	5.56	0.0	17.65	17.65	9.62	28.85	11.54
G#4	16.67	0.0	11.11	0.0	0.0	11.76	0.0	0.0	0.0

Figure a5.10. *Ls Xp* Mb

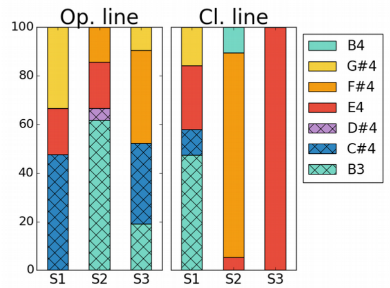

Table a5.10. *Ls Xp* Mb

	Opening line			Closing line		
	S1	S2	S3	S1	S2	S3
B3	0.0	61.9	19.05	47.37	0.0	0.0
C#4	47.62	0.0	33.33	10.53	0.0	0.0
D#4	0.0	4.76	0.0	0.0	0.0	0.0
E4	19.05	19.05	0.0	26.32	5.26	100.0
F#4	0.0	14.29	38.1	0.0	84.21	0.0
G#4	33.33	0.0	9.52	15.79	0.0	0.0
B4	0.0	0.0	0.0	0.0	10.53	0.0

Figure a5.11. *Da Eh* Mb

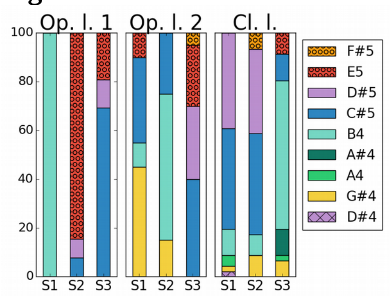

Table a5.11. *Da Eh* Mb

	Opening line 1			Opening line 2			Closing line		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
D#4	0.0	0.0	0.0	0.0	0.0	0.0	2.17	0.0	0.0
G#4	0.0	0.0	0.0	45.0	15.0	0.0	2.17	8.7	6.52
A4	0.0	0.0	0.0	0.0	0.0	0.0	4.35	0.0	2.17
A#4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.87
B4	100.0	0.0	0.0	10.0	60.0	0.0	10.87	8.7	60.87
C#5	0.0	7.69	69.23	35.0	25.0	40.0	41.3	41.3	10.87
D#5	0.0	7.69	11.54	0.0	0.0	30.0	39.13	34.78	0.0
E5	0.0	84.62	19.23	10.0	0.0	25.0	0.0	0.0	8.7
F#5	0.0	0.0	0.0	0.0	0.0	5.0	0.0	6.52	0.0

Figure a5.12. *Da Xp* Mb

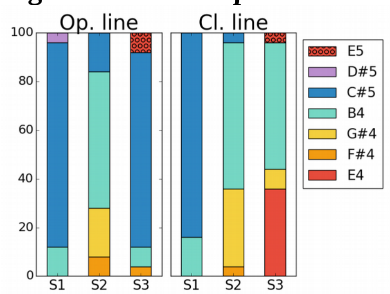

Table a5.12. *Da Xp* Mb

	Opening line			Closing line		
	S1	S2	S3	S1	S2	S3
E4	0.0	0.0	0.0	0.0	0.0	36.0
F#4	0.0	8.0	4.0	0.0	4.0	0.0
G#4	0.0	20.0	0.0	0.0	32.0	8.0
B4	12.0	56.0	8.0	16.0	60.0	52.0
C#5	84.0	16.0	80.0	84.0	4.0	0.0
D#5	4.0	0.0	0.0	0.0	0.0	0.0
E5	0.0	0.0	8.0	0.0	0.0	4.0

Figure a5.13. *Ls Xp* Kb

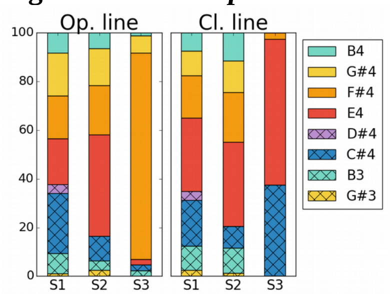

Table a5.13. *Ls Xp* Kb

	Opening line			Closing line		
	S1	S2	S3	S1	S2	S3
G#3	1.18	2.53	0.0	2.5	1.28	0.0
B3	8.24	3.8	2.35	10.0	10.26	0.0
C#4	24.71	10.13	2.35	18.75	8.97	37.5
D#4	3.53	0.0	0.0	3.75	0.0	0.0
E4	18.82	41.77	2.35	30.0	34.62	60.0
F#4	17.65	20.25	84.71	17.5	20.51	2.5
G#4	17.65	15.19	7.059	10.0	12.82	0.0
B4	8.24	6.33	1.18	7.5	11.54	0.0

Figure a5.14. ***Da Xp*** **Kb**

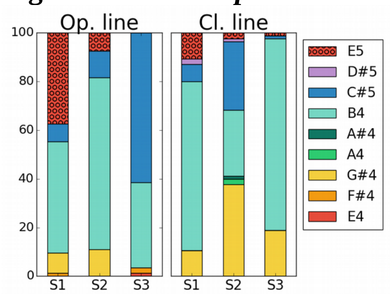

Table a5.14. ***Da Xp*** **Kb**

	Opening line			Closing line		
	S1	S2	S3	S1	S2	S3
E4	0.0	0.0	1.2	0.0	0.0	0.0
F#4	1.2	0.0	2.41	0.0	0.0	0.0
G#4	8.43	10.98	0.0	10.59	37.65	18.82
A4	0.0	0.0	0.0	0.0	2.35	0.0
A#4	0.0	0.0	0.0	0.0	1.18	0.0
B4	45.78	70.73	34.94	69.41	27.06	78.82
C#5	7.23	10.98	61.45	7.06	28.24	1.18
D#5	0.0	0.0	0.0	2.35	1.18	0.0
E5	37.35	7.32	0.0	10.59	2.35	1.18

a6. Melodic density as notes

The abbreviations used in the headings of the tables contained in this section stand for the following concepts:

- In. Index of the sample score, as it appears in the related plot
- M. Median
- Q1 First Quartile
- Q3 Third Quartile
- L.f. Lower Fence
- U.f. Upper Fence

Figure a6.1. ***Ls Eh*** **Yb**

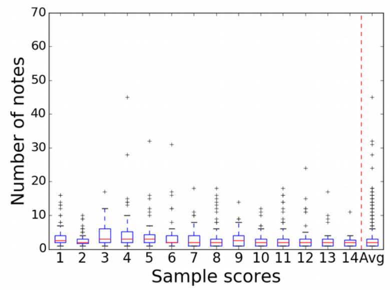

Table a6.1. ***Ls Eh*** **Yb**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	2.5	2.0	4.0	1.0	7.0	12, 16, 8, 10, 10, 14, 13, 13, 8, 16
2	2.0	1.75	3.0	1.0	4.0	5, 6, 6, 7, 5, 5, 6, 5, 9, 6, 5, 9, 6, 6, 10
3	3.0	2.0	6.0	1.0	12.0	17
4	3.0	2.0	5.25	1.0	10.0	14, 28, 15, 45, 13, 14
5	3.0	2.0	4.25	1.0	7.0	16, 10, 32, 12, 15, 11
6	2.0	2.0	4.0	1.0	6.0	16, 8, 31, 12, 17, 12
7	2.0	1.0	4.0	1.0	8.0	10, 18, 10, 11
8	2.0	1.0	3.0	1.0	6.0	8, 13, 14, 15, 12, 16, 18, 9, 11, 8, 8, 8, 8
9	2.5	1.0	4.0	1.0	8.0	14, 9, 9
10	2.0	1.0	3.0	1.0	6.0	12, 7, 7, 11, 10
11	2.0	1.0	3.0	1.0	6.0	8, 14, 14, 16, 12, 16, 18, 9, 11, 8, 8, 8, 8
12	2.0	1.0	3.0	1.0	5.0	12, 12, 11, 11, 15, 7, 24
13	2.0	1.0	3.0	1.0	4.0	8, 9, 17, 10
14	2.0	1.0	2.75	1.0	4.0	11
Av	2.0	1.0	3.0	1.0	6.0	12, 16, 8, 10, 7, 10, 14, 13, 13, 8, 16, 7, 9, 9, 10, 17, 7, 7, 10, 12, 8, 14, 28, 10, 15, 45, 9, 13, 14, 16, 10, 7, 32, 12, 15, 11, 16, 8, 31, 12, 17, 12, 10, 18, 8, 10, 11, 7, 8, 13, 14, 15, 12, 16, 18, 9, 11, 8, 8, 8, 8, 14, 9, 8, 9, 12, 7, 7, 11, 10, 8, 14, 14, 16, 12, 16, 18, 9, 11, 8, 8, 8, 8, 12, 12, 11, 11, 15, 7, 24, 8, 9, 17, 10, 11

Figure a6.2. *Ls Eh* Yb O1

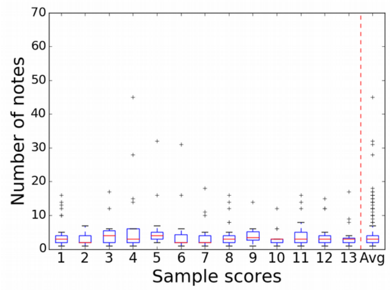

Table a6.2. *Ls Eh* Yb O1

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.0	2.0	4.0	1.0	5.0	12, 16, 10, 10, 14, 13
2	2.0	2.0	4.0	1.0	7.0	
3	4.0	2.0	5.5	1.0	6.0	17, 12
4	3.0	2.0	6.0	1.0	6.0	14, 28, 15, 45
5	4.0	3.0	5.0	2.0	7.0	16, 32
6	2.0	2.0	4.25	1.0	6.0	16, 31
7	2.0	2.0	4.0	1.0	5.0	10, 18, 11
8	3.0	2.0	4.0	1.0	5.0	8, 14, 12, 16, 8
9	3.5	2.75	5.25	1.0	6.0	14
10	3.0	2.0	3.0	1.0	3.0	6, 12, 6
11	3.0	2.0	5.0	1.0	8.0	14, 12, 16
12	3.0	2.0	4.0	1.0	5.0	12, 12, 15
13	3.0	2.0	3.25	1.0	4.0	8, 9, 17
Av	3.0	2.0	4.0	1.0	7.0	12, 16, 10, 10, 14, 13, 17, 12, 14, 28, 15, 45, 16, 32, 16, 31, 10, 18, 11, 8, 14, 12, 16, 8, 14, 12, 8, 14, 12, 16, 8, 12, 12, 15, 8, 9, 17

Figure a6.3. ***Ls Eh*** **Yb O2**

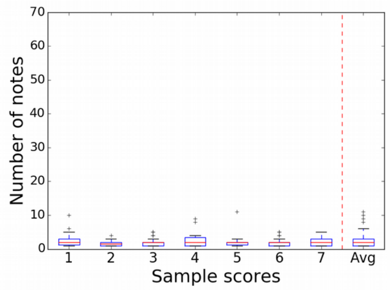

Table a6.3. ***Ls Eh*** **Yb O2**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	2.0	1.25	3.0	1.0	5.0	6, 10
2	1.5	1.0	2.0	1.0	3.0	4
3	2.0	1.0	2.0	1.0	3.0	4, 5, 5, 4
4	2.0	1.0	3.5	1.0	4.0	9, 8
5	2.0	1.25	2.0	1.0	3.0	11
6	2.0	1.0	2.0	1.0	3.0	4, 5, 5, 4
7	2.0	1.0	3.0	1.0	5.0	
Av	2.0	1.0	3.0	1.0	6.0	10, 9, 8, 11

Figure a6.4. *Ls Eh* Yb C

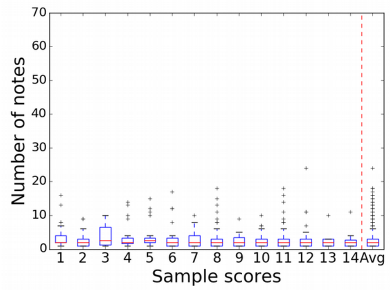

Table a6.4. *Ls Eh* Yb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	2.0	2.0	4.0	1.0	7.0	8, 13, 8, 16
2	2.0	1.0	3.0	1.0	6.0	9, 9
3	2.5	1.25	6.5	1.0	10.0	
4	2.0	1.75	3.25	1.0	4.0	10, 9, 13, 14
5	2.5	2.0	3.25	1.0	4.0	10, 12, 15, 11
6	2.0	1.0	3.25	1.0	4.0	8, 12, 17, 12
7	2.0	1.0	4.0	1.0	8.0	10
8	2.0	1.0	3.0	1.0	6.0	13, 15, 18, 9, 11, 8, 8, 8
9	2.0	1.0	3.5	1.0	5.0	9
10	2.0	1.0	3.0	1.0	6.0	7, 7, 10
11	2.0	1.0	3.0	1.0	6.0	14, 16, 18, 9, 11, 8, 8, 8
12	2.0	1.0	3.0	1.0	5.0	11, 11, 7, 24
13	2.0	1.0	3.0	1.0	3.0	10
14	2.0	1.0	2.75	1.0	4.0	11
Av	2.0	1.0	3.0	1.0	6.0	8, 7, 13, 8, 16, 9, 9, 7, 7, 10, 8, 10, 9, 13, 14, 10, 12, 15, 11, 8, 12, 17, 12, 8, 10, 7, 13, 15, 18, 9, 11, 8, 8, 8, 9, 7, 7, 10, 14, 16, 18, 9, 11, 8, 8, 8, 11, 11, 7, 24, 10, 11

Figure a6.5. *Ls Xp* Yb

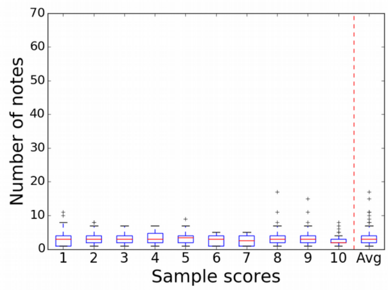

Figure a6.6. *Ls Xp* Yb O

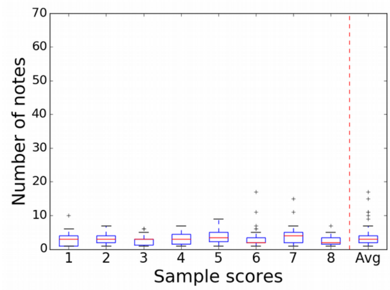

Table a6.5. *Ls Xp* Yb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.0	1.0	4.0	1.0	8.0	10, 11
2	3.0	2.0	4.0	1.0	7.0	8, 8
3	3.0	2.0	4.0	1.0	7.0	
4	3.0	2.0	4.75	1.0	7.0	
5	3.5	2.0	4.0	1.0	7.0	9
6	3.0	1.0	4.0	1.0	5.0	
7	2.5	1.0	4.0	1.0	5.0	
8	3.0	2.0	4.0	1.0	7.0	8, 11, 17
9	3.0	2.0	4.0	1.0	7.0	15, 8, 11
10	2.0	2.0	3.0	1.0	4.0	6, 8, 5, 7, 5
Av	3.0	2.0	4.0	1.0	7.0	10, 11, 8, 8, 8, 9, 8, 11, 17, 15, 8, 11, 8

Table a6.6. *Ls Xp* Yb O

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.0	1.0	4.0	1.0	6.0	10
2	3.0	2.0	4.0	1.0	7.0	
3	3.0	1.25	3.0	1.0	5.0	6, 6, 6
4	3.0	1.5	4.5	1.0	7.0	
5	3.5	2.25	5.0	1.0	9.0	
6	2.0	2.0	3.5	1.0	5.0	6, 7, 6, 11, 17
7	4.0	2.0	5.0	1.0	7.0	15, 11
8	2.0	1.5	3.5	1.0	5.0	7
Av	3.0	2.0	4.0	1.0	7.0	10, 9, 11, 17, 15, 11

Figure a6.7. ***Ls Xp*** **Yb C**

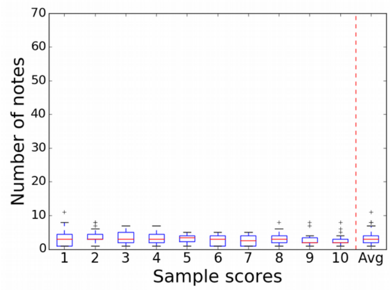

Figure a6.8. ***Da Eh*** **Yb**

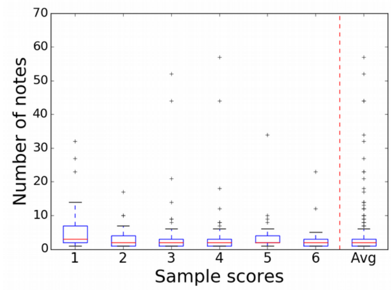

Table a6.7. ***Ls Xp*** **Yb C**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.0	1.0	4.5	1.0	8.0	11
2	3.0	3.0	4.5	1.0	6.0	7, 8, 8
3	3.0	2.0	5.0	1.0	7.0	
4	3.0	2.0	4.5	1.0	7.0	
5	3.5	2.25	4.0	1.0	5.0	
6	3.0	1.0	4.0	1.0	5.0	
7	2.5	1.0	4.0	1.0	5.0	
8	3.0	2.0	4.0	1.0	6.0	8
9	2.0	2.0	3.5	1.0	4.0	7, 8
10	2.0	2.0	3.0	1.0	4.0	6, 8, 5
Av	3.0	2.0	4.0	1.0	7.0	11, 8, 8, 8, 8, 8, 8

Table a6.8. ***Da Eh*** **Yb**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.0	2.0	7.0	1.0	14.0	27, 32, 23
2	2.0	1.0	4.0	1.0	7.0	10, 10, 17
3	2.0	1.0	3.0	1.0	6.0	9, 44, 14, 21, 9, 52, 8
4	2.0	1.0	3.0	1.0	6.0	8, 8, 44, 12, 18, 7, 57, 8
5	2.0	2.0	4.0	1.0	6.0	10, 34, 8, 9
6	2.0	1.0	3.0	1.0	5.0	12, 23
Av	2.0	1.0	3.0	1.0	6.0	13, 14, 7, 10, 7, 7, 12, 27, 14, 12, 7, 8, 32, 10, 7, 23, 10, 7, 10, 17, 9, 44, 14, 21, 9, 52, 8, 8, 8, 44, 12, 18, 7, 57, 8, 10, 34, 8, 9, 12, 23

Figure a6.9. ***Da Eh*** **Yb O1**

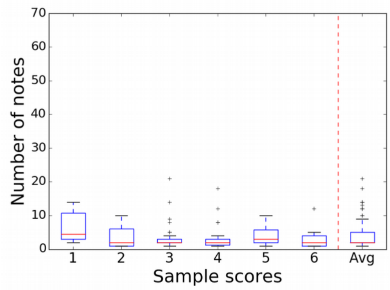

Figure a6.10. ***Da Eh*** **Yb O2**

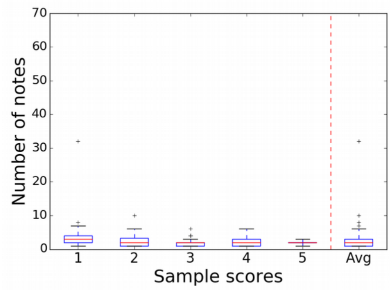

Table a6.9. ***Da Eh*** **Yb O1**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	4.5	3.0	10.75	2.0	14.0	
2	2.0	1.0	6.0	1.0	10.0	
3	2.0	2.0	3.0	1.0	4.0	5, 9, 14, 5, 21, 8
4	2.0	1.25	3.0	1.0	4.0	8, 8, 12, 18, 8
5	3.0	2.0	5.75	1.0	10.0	
6	2.0	1.0	4.0	1.0	5.0	12
Av	2.0	2.0	5.0	1.0	9.0	13, 14, 14, 12, 10, 14, 21, 12, 18, 10, 12

Table a6.10. ***Da Eh*** **Yb O2**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.0	2.0	4.0	1.0	7.0	8, 32
2	2.0	1.0	3.25	1.0	6.0	10
3	2.0	1.0	2.0	1.0	3.0	4, 4, 4, 4, 4, 4, 6
4	2.0	1.0	3.0	1.0	6.0	
5	2.0	2.0	2.0	1.0	3.0	
Av	2.0	1.0	3.0	1.0	6.0	7, 8, 32, 10

Figure a6.11. ***Da Eh*** **Yb C**

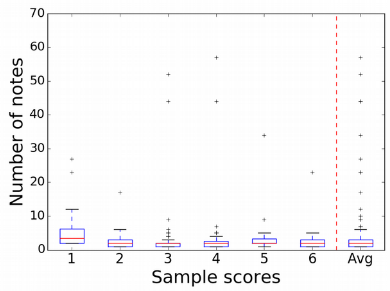

Table a6.11. ***Da Eh*** **Yb C**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.5	2.0	6.25	2.0	12.0	27, 23
2	2.0	1.0	3.0	1.0	6.0	17
3	2.0	1.0	2.0	1.0	3.0	5, 4, 5, 4, 44, 4, 5, 9, 4, 4, 5, 4, 5, 4, 52, 4, 5, 6
4	2.0	1.0	2.5	1.0	4.0	5, 5, 44, 5, 5, 7, 5, 5, 5, 5, 57, 5
5	2.0	2.0	3.25	1.0	5.0	34, 9
6	2.0	1.0	3.0	1.0	5.0	23
Av	2.0	1.0	3.0	1.0	6.0	10, 7, 12, 27, 10, 7, 23, 17, 44, 9, 52, 44, 7, 57, 34, 9, 23

Figure a6.12. *Da Xp* Yb

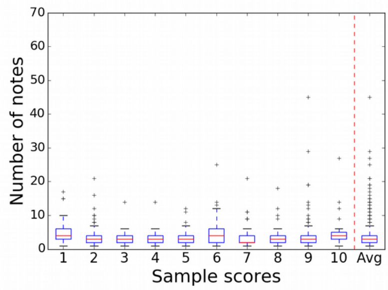

Table a6.12. *Da Xp* Yb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	4.0	3.0	6.0	1.0	10.0	17, 15, 15
2	3.0	2.0	4.0	1.0	7.0	16, 10, 10, 21, 8, 9, 8, 8, 12, 8
3	3.0	2.0	4.0	1.0	6.0	14
4	3.0	2.0	4.0	1.0	6.0	14
5	3.0	2.0	4.0	1.0	7.0	12, 8, 11
6	4.0	2.0	6.0	1.0	12.0	25, 13, 14
7	2.0	2.0	4.0	1.0	6.0	21, 9, 11, 11, 9, 9
8	3.0	2.0	4.0	1.0	6.0	18, 12, 9, 10
9	3.0	2.0	4.0	1.0	7.0	8, 10, 13, 29, 9, 19, 8, 9, 45, 19, 8, 12, 14, 8
10	4.0	3.0	5.0	1.0	6.0	14, 12, 9, 27
Av	3.0	2.0	4.0	1.0	7.0	17, 15, 10, 15, 16, 10, 10, 21, 8, 9, 8, 8, 12, 8, 14, 14, 12, 8, 11, 25, 13, 14, 12, 9, 9, 11, 21, 9, 11, 11, 9, 9, 18, 12, 9, 10, 8, 10, 13, 29, 9, 19, 8, 9, 45, 19, 8, 12, 14, 8, 14, 12, 9, 27

Figure a6.13. *Da Xp* Yb O

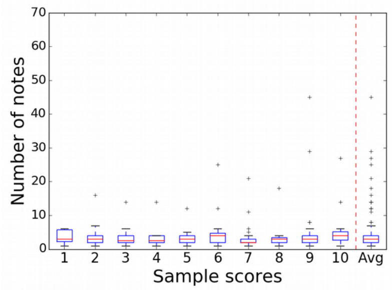

Table a6.13. *Da Xp* Yb O

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.0	2.25	5.75	1.0	6.0	
2	3.0	2.0	4.0	1.0	7.0	16
3	2.5	2.0	4.0	1.0	6.0	14
4	2.5	2.0	4.0	1.0	4.0	14
5	3.0	2.0	4.0	1.0	5.0	12
6	4.0	2.0	4.75	1.0	6.0	25, 12
7	2.0	2.0	3.0	1.0	4.0	5, 21, 11, 6
8	3.0	2.0	3.5	1.0	4.0	18
9	3.0	2.0	4.0	1.0	6.0	29, 45, 8, 8
10	4.0	2.75	5.25	1.0	6.0	14, 27
Av	3.0	2.0	4.0	1.0	7.0	16, 14, 14, 12, 25, 12, 21, 11, 18, 29, 45, 8, 8, 14, 27

Figure a6.14. ***Da Xp*** **Yb C**

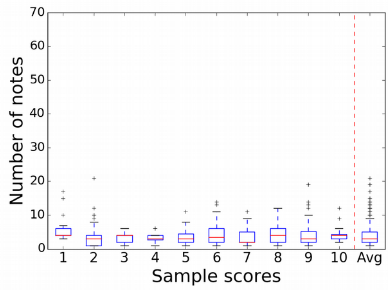

Table a6.14. ***Da Xp*** **Yb C**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	4.0	4.0	6.0	3.0	7.0	17, 15, 10, 15
2	3.0	1.0	4.0	1.0	8.0	10, 10, 21, 9, 12
3	4.0	2.0	4.0	1.0	6.0	
4	3.0	2.75	4.0	1.0	4.0	6, 6
5	3.0	2.0	4.5	1.0	8.0	11
6	3.5	2.0	6.0	1.0	11.0	13, 14
7	2.0	2.0	5.0	1.0	9.0	11
8	4.0	2.0	6.0	1.0	12.0	
9	3.0	2.0	5.25	1.0	10.0	13, 19, 19, 12, 14
10	4.0	3.0	4.25	2.0	6.0	12, 9
Av	3.0	2.0	5.0	1.0	9.0	17, 15, 10, 15, 10, 10, 21, 12, 11, 13, 14, 11, 11, 12, 10, 10, 13, 19, 19, 12, 14, 12

Figure a6.15. *Ls Eh* Mb

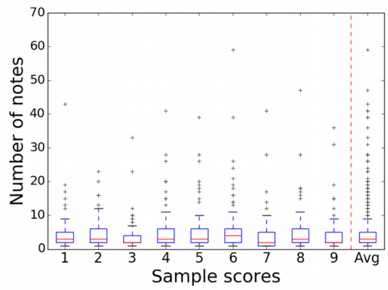

Table a6.15. *Ls Eh* Mb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.0	2.0	5.0	1.0	9.0	17, 43, 13, 19, 12, 15
2	3.0	2.0	6.0	1.0	12.0	20, 23, 13, 16, 16
3	2.0	2.0	4.0	1.0	7.0	23, 10, 9, 12, 8, 10, 8, 9, 10, 33
4	3.0	2.0	6.0	1.0	11.0	20, 41, 17, 26, 20, 15, 28, 13, 15
5	3.0	2.0	6.0	1.0	10.0	19, 39, 17, 26, 20, 15, 28, 14, 18
6	4.0	2.0	6.0	1.0	11.0	14, 26, 59, 16, 14, 24, 19, 16, 13, 21, 18, 39
7	2.0	1.0	5.0	1.0	10.0	17, 41, 12, 14, 28
8	3.0	2.0	6.0	1.0	11.0	18, 47, 16, 18, 15, 17, 28
9	2.0	2.0	5.0	1.0	9.0	15, 19, 31, 12, 10, 15, 36
Av	3.0	2.0	5.0	1.0	9.0	17, 43, 13, 19, 12, 15, 20, 23, 12, 13, 16, 12, 16, 23, 10, 12, 10, 10, 33, 10, 20, 41, 17, 26, 20, 11, 15, 10, 28, 13, 15, 19, 39, 17, 26, 20, 10, 15, 10, 28, 14, 18, 14, 26, 10, 59, 16, 14, 24, 19, 16, 10, 11, 10, 13, 21, 11, 18, 39, 17, 10, 41, 12, 14, 10, 28, 10, 18, 47, 16, 11, 18, 11, 10, 15, 17, 28, 15, 19, 31, 12, 10, 15, 36

Figure a6.16. *Ls Eh* Mb O1

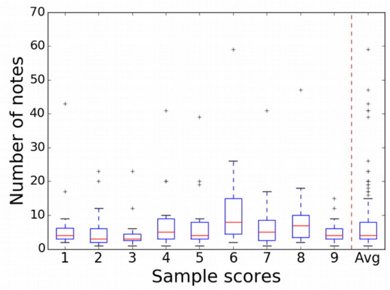

Table a6.16. *Ls Eh* Mb O1

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	4.0	3.0	6.25	2.0	9.0	17, 43
2	3.0	2.0	6.0	1.0	12.0	20, 23
3	3.0	2.5	4.5	1.0	6.0	23, 12
4	5.0	3.0	9.0	1.0	10.0	20, 41, 20
5	4.0	3.0	8.0	1.0	9.0	19, 39, 20
6	8.0	4.5	15.0	2.0	26.0	59
7	5.0	2.5	8.5	1.0	17.0	41
8	7.0	3.5	10.0	2.0	18.0	47
9	4.0	3.0	6.0	1.0	9.0	15, 12
Av	4.0	3.0	8.0	1.0	15.0	17, 43, 20, 23, 23, 20, 41, 20, 19, 39, 20, 26, 59, 19, 16, 17, 41, 18, 47

Figure a6.17. *Ls Eh* Mb O2

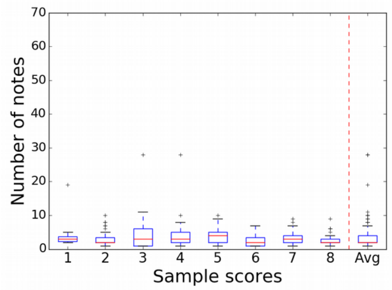

Table a6.17. *Ls Eh* Mb O2

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.0	2.25	3.75	2.0	5.0	19
2	2.0	2.0	3.5	1.0	5.0	8, 7, 8, 7, 10, 6
3	3.0	1.0	6.0	1.0	11.0	28
4	3.0	2.0	5.0	1.0	8.0	10, 28
5	4.0	2.0	5.0	1.0	9.0	10
6	2.0	1.0	3.5	1.0	7.0	
7	3.0	2.0	4.0	1.0	7.0	8, 9
8	2.0	2.0	3.0	1.0	4.0	5, 6, 6, 6, 9, 6
Av	2.0	2.0	4.0	1.0	7.0	19, 8, 8, 10, 8, 11, 8, 8, 8, 8, 28, 8, 10, 8, 8, 8, 28, 10, 9, 8, 9, 9

Figure a6.18. *Ls Eh* Mb C

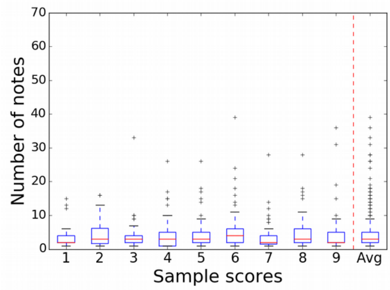

Table a6.18. *Ls Eh* Mb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	2.0	2.0	4.0	1.0	6.0	13, 12, 15
2	3.0	1.75	6.25	1.0	13.0	16, 16
3	3.0	2.0	4.0	1.0	7.0	10, 9, 10, 9, 33
4	3.0	1.0	5.0	1.0	10.0	17, 26, 15, 13, 15
5	3.0	2.0	5.0	1.0	9.0	17, 26, 15, 10, 14, 18
6	4.0	2.0	6.0	1.0	11.0	16, 14, 24, 13, 21, 18, 39
7	2.0	1.5	4.0	1.0	6.0	9, 12, 9, 8, 14, 8, 10, 28
8	3.0	2.0	6.0	1.0	11.0	16, 18, 15, 17, 28
9	2.0	2.0	5.0	1.0	9.0	19, 31, 10, 15, 36
Av	3.0	2.0	5.0	1.0	9.0	13, 12, 15, 12, 13, 16, 16, 10, 10, 33, 17, 26, 15, 10, 13, 15, 17, 26, 15, 10, 14, 18, 16, 14, 24, 10, 11, 13, 21, 11, 18, 39, 12, 14, 10, 28, 16, 11, 18, 15, 17, 28, 19, 31, 10, 15, 36

Figure a6.19. *Ls Xp* Mb

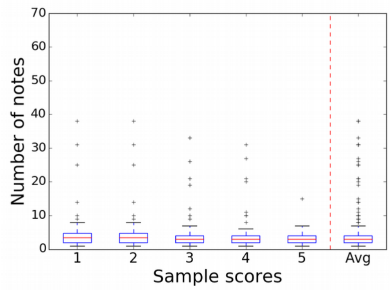

Figure a6.20. *Ls Xp* Mb O

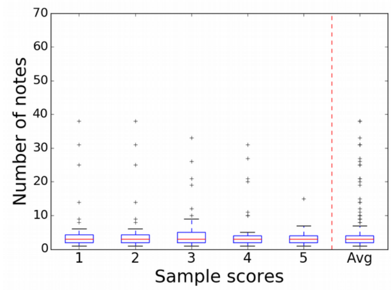

Table a6.19. *Ls Xp* Mb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.5	2.0	4.75	1.0	8.0	14, 10, 38, 25, 9, 31
2	3.5	2.0	4.75	1.0	8.0	14, 10, 38, 25, 9, 31
3	3.0	2.0	4.0	1.0	7.0	21, 33, 10, 26, 9, 19, 12
4	3.0	2.0	4.0	1.0	6.0	27, 31, 10, 20, 8, 10, 21, 11
5	3.0	2.0	4.0	1.0	7.0	15
Av	3.0	2.0	4.0	1.0	7.0	14, 10, 8, 38, 25, 9, 31, 14, 10, 8, 38, 25, 9, 31, 21, 33, 10, 26, 9, 19, 12, 27, 31, 10, 20, 8, 10, 21, 11, 15

Table a6.20. *Ls Xp* Mb O

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.0	2.0	4.25	1.0	6.0	14, 8, 38, 25, 9, 31
2	3.0	2.0	4.25	1.0	6.0	14, 8, 38, 25, 9, 31
3	3.0	2.0	5.0	1.0	9.0	21, 33, 10, 26, 19, 12
4	3.0	2.0	4.0	1.0	5.0	27, 31, 10, 20, 10, 21, 11
5	3.0	2.0	4.0	1.0	7.0	15
Av	3.0	2.0	4.0	1.0	7.0	14, 8, 38, 25, 9, 31, 14, 8, 38, 25, 9, 31, 21, 33, 10, 26, 9, 19, 12, 27, 31, 10, 20, 10, 21, 11, 15

Figure a6.21. *Ls Xp* Mb C

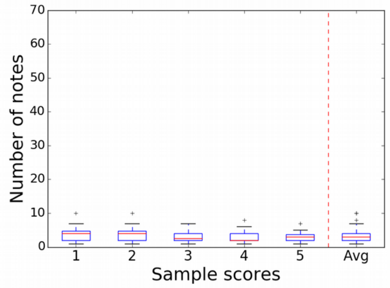

Table a6.21. *Ls Xp* Mb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	4.0	2.0	4.75	1.0	7.0	10
2	4.0	2.0	4.75	1.0	7.0	10
3	2.5	2.0	4.0	1.0	7.0	
4	2.0	2.0	4.0	1.0	6.0	8
5	3.0	2.0	3.75	1.0	5.0	7
Av	3.0	2.0	4.0	1.0	7.0	10, 10, 8

Figure a6.22. *Da Eh* Mb

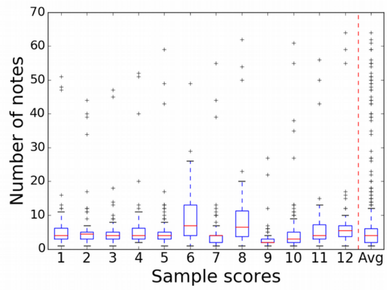

Table a6.22. *Da Eh* Mb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	4.0	3.0	6.25	1.0	11.0	47, 12, 48, 16, 51, 12, 13
2	4.5	3.0	5.0	1.0	7.0	11, 44, 12, 34, 12, 9, 11, 39, 12, 40, 11, 17
3	4.0	3.0	5.0	1.0	8.0	13, 9, 47, 18, 9, 10, 9, 14, 45
4	4.0	3.0	6.25	2.0	11.0	51, 13, 52, 40, 12, 20
5	4.0	3.0	5.0	1.0	8.0	12, 49, 13, 43, 12, 59, 13, 9, 10, 13, 9, 9, 11, 17
6	7.0	4.0	13.0	1.0	26.0	29, 49, 70
7	4.0	2.0	4.0	1.0	7.0	10, 8, 55, 11, 44, 13, 12, 10, 10, 39, 10
8	6.5	3.75	11.25	1.0	20.0	23, 62, 50, 54
9	2.0	2.0	3.0	1.0	4.0	12, 6, 6, 6, 6, 5, 7, 5, 6, 6, 22, 6, 6, 6, 27
10	3.0	2.0	5.0	1.0	9.0	13, 61, 11, 35, 13, 11, 11, 10, 55, 10, 13, 10, 27, 12, 38
11	4.0	3.0	7.25	1.0	13.0	50, 43, 15, 56
12	5.5	3.75	7.0	1.0	10.0	16, 59, 12, 55, 17, 64, 12, 15
Av	4.0	2.0	6.0	1.0	12.0	47, 48, 16, 51, 13, 44, 34, 39, 40, 17, 13, 47, 18, 14, 45, 51, 13, 52, 40, 20, 49, 13, 43, 59, 13, 13, 17, 29, 14, 13, 13, 13, 49, 13, 26, 15, 18, 14, 70, 18, 55, 44, 13, 39, 23, 62, 17, 50, 20, 13, 15, 14, 13, 54, 17, 13, 22, 27, 13, 61, 35, 13, 55, 13, 27, 38, 13, 50, 43, 15, 56, 16, 59, 55, 17, 64, 15

Figure a6.23. ***Da Eh*** **Mb O1**

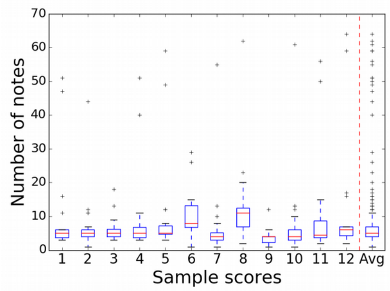

Table a6.23. ***Da Eh*** **Mb O1**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	5.0	3.75	6.0	3.0	6.0	11, 47, 16, 51
2	5.0	4.0	6.0	1.0	7.0	11, 44, 12, 11
3	5.0	4.0	6.25	3.0	9.0	13, 18
4	5.0	3.75	6.75	3.0	11.0	51, 40
5	5.0	4.75	7.25	3.0	8.0	12, 49, 12, 59
6	8.0	6.75	13.25	1.0	15.0	29, 26
7	4.0	3.0	5.25	1.0	8.0	10, 55, 13
8	11.0	7.0	12.5	2.0	20.0	23, 62
9	4.0	2.25	4.0	1.0	6.0	12
10	4.0	3.0	6.0	1.0	10.0	13, 61, 13, 12
11	4.5	3.75	8.75	2.0	15.0	50, 56
12	6.0	4.25	7.0	2.0	7.0	16, 59, 17, 64
Av	5.0	4.0	7.0	1.0	11.0	47, 16, 51, 44, 12, 13, 18, 51, 40, 12, 49, 12, 59, 29, 14, 13, 13, 13, 26, 15, 55, 13, 23, 62, 20, 13, 12, 13, 61, 13, 12, 13, 50, 15, 56, 16, 59, 17, 64

Figure a6.24. ***Da Eh*** **Mb O2**

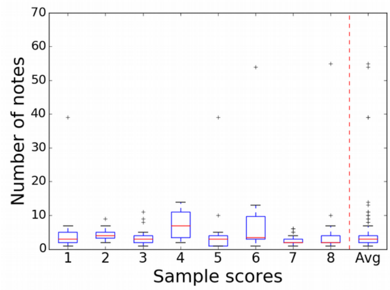

Table a6.24. ***Da Eh*** **Mb O2**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.0	2.0	5.0	1.0	7.0	39
2	4.0	3.25	5.0	2.0	7.0	9
3	3.0	2.0	4.0	1.0	5.0	8, 9, 11
4	7.0	3.5	11.0	2.0	14.0	70
5	3.0	1.0	4.0	1.0	5.0	10, 39
6	3.5	3.0	9.75	1.0	13.0	54
7	2.0	2.0	3.0	1.0	4.0	6, 5, 5, 6, 6, 6
8	2.0	2.0	4.0	1.0	7.0	10, 55
Av	3.0	2.0	4.0	1.0	7.0	39, 9, 8, 9, 11, 8, 14, 70, 10, 39, 11, 11, 13, 54, 10, 55

Figure a6.25. ***Da Eh*** **Mb C**

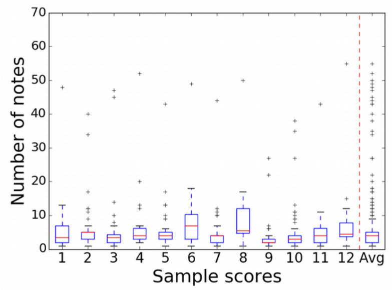

Table a6.25. ***Da Eh*** **Mb C**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	3.5	2.0	7.0	1.0	13.0	48
2	5.0	3.0	5.0	1.0	7.0	12, 34, 9, 11, 12, 40, 17
3	3.5	2.0	4.25	1.0	7.0	47, 10, 8, 14, 45
4	4.0	3.0	6.25	2.0	7.0	13, 52, 12, 20
5	4.0	3.0	5.0	1.0	6.0	13, 43, 13, 9, 10, 13, 9, 17
6	7.0	3.0	10.25	1.0	18.0	49
7	4.0	2.0	4.0	1.0	7.0	11, 44, 12, 10, 10
8	5.5	4.75	12.0	1.0	17.0	50
9	2.0	2.0	3.0	1.0	4.0	6, 6, 7, 6, 22, 6, 27
10	3.0	2.0	4.0	1.0	6.0	11, 35, 9, 11, 11, 10, 13, 27, 9, 8, 38
11	4.0	2.0	6.25	1.0	11.0	43
12	4.5	3.75	7.75	1.0	12.0	55, 15
Av	4.0	2.0	5.0	1.0	9.0	12, 48, 12, 13, 12, 34, 11, 12, 40, 17, 47, 10, 14, 45, 13, 52, 12, 20, 13, 43, 13, 10, 13, 17, 13, 49, 18, 11, 18, 10, 10, 11, 11, 44, 12, 10, 10, 17, 10, 50, 12, 12, 15, 11, 14, 17, 13, 22, 27, 11, 35, 11, 11, 10, 13, 27, 38, 11, 43, 12, 55, 12, 10, 15

Figure a6.26. *Da Xp* Mb

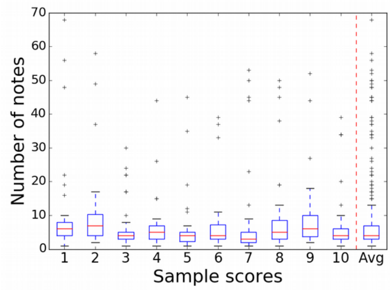

Table a6.26. *Da Xp* Mb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	6.0	4.0	8.0	1.0	10.0	68, 56, 48, 16, 22, 19
2	7.0	4.0	10.25	2.0	17.0	37, 58, 49
3	4.0	3.0	5.0	1.0	8.0	17, 24, 30, 22, 17, 10, 22, 17
4	5.0	3.0	7.0	1.0	9.0	26, 15, 44, 15
5	4.0	2.25	5.0	1.0	7.0	19, 11, 35, 45, 12
6	4.0	3.0	7.25	1.0	11.0	33, 39, 37
7	3.0	2.0	5.0	1.0	9.0	45, 53, 50, 23, 13, 44
8	5.0	3.0	8.5	1.0	13.0	45, 38, 48, 50, 19, 19
9	6.0	3.75	10.0	2.0	18.0	27, 52, 44
10	4.0	3.0	6.0	1.0	10.0	20, 39, 34, 34, 13, 34
Av	4.0	3.0	7.0	1.0	13.0	68, 56, 48, 16, 22, 19, 37, 58, 49, 17, 15, 17, 24, 30, 22, 17, 22, 17, 26, 15, 44, 15, 19, 35, 45, 33, 39, 37, 45, 53, 50, 23, 44, 45, 38, 48, 50, 19, 19, 27, 15, 52, 44, 18, 20, 39, 34, 34, 34

Figure a6.27. ***Da Xp*** **Mb O**

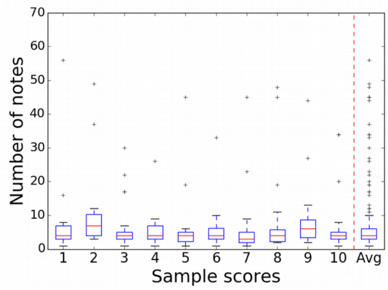

Table a6.27. ***Da Xp*** **Mb O**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	4.0	3.0	7.0	1.0	8.0	56, 16
2	7.0	4.0	10.25	3.0	12.0	37, 49
3	4.0	3.0	5.0	1.0	7.0	17, 30, 17, 22
4	4.0	3.0	7.0	1.0	9.0	26
5	4.0	2.25	5.0	1.0	6.0	19, 45
6	4.0	3.0	6.25	1.0	10.0	33
7	3.0	2.0	5.0	1.0	9.0	45, 23
8	4.0	2.25	5.75	2.0	11.0	45, 48, 19
9	6.0	3.5	8.75	2.0	13.0	27, 44
10	4.0	3.0	5.0	1.0	8.0	20, 34, 34
Av	4.0	3.0	6.0	1.0	10.0	56, 16, 12, 37, 12, 11, 49, 17, 30, 17, 22, 26, 19, 45, 33, 45, 23, 45, 11, 48, 19, 27, 13, 44, 20, 34, 34

Figure a6.28. *Da Xp* Mb C

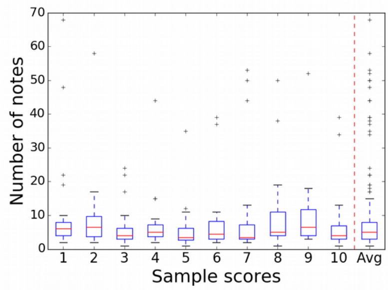

Table a6.28. *Da Xp* Mb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	6.0	4.0	8.0	2.0	10.0	68, 48, 22, 19
2	6.5	3.75	9.75	2.0	17.0	58
3	4.0	3.0	6.25	1.0	10.0	24, 22, 17
4	5.0	3.75	7.25	2.0	9.0	15, 44, 15
5	3.5	2.75	6.25	1.0	11.0	35, 12
6	4.5	3.0	8.25	2.0	11.0	39, 37
7	3.5	3.0	7.25	2.0	13.0	53, 50, 44
8	5.0	4.0	11.0	1.0	19.0	38, 50
9	6.5	4.0	11.75	3.0	18.0	52
10	4.0	3.0	7.0	1.0	13.0	39, 34
Av	5.0	3.0	8.0	1.0	15.0	68, 48, 22, 19, 58, 17, 24, 22, 17, 44, 35, 39, 37, 53, 50, 44, 38, 50, 19, 52, 18, 39, 34

Figure a6.29. *Ls Xp* Kb

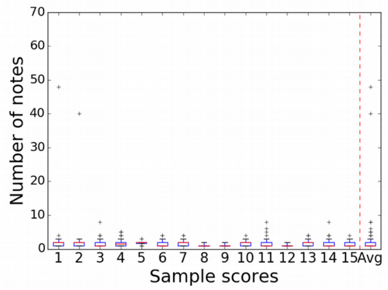

Table a6.29. *Ls Xp* Kb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	2.0	1.0	2.0	1.0	3.0	4, 48
2	2.0	1.0	2.0	1.0	3.0	40
3	1.0	1.0	2.0	1.0	3.0	8, 4, 4, 4
4	1.5	1.0	2.0	1.0	3.0	5, 4, 4, 4, 4, 4, 4, 5, 5, 5, 4
5	2.0	1.75	2.0	1.75	2.0	1, 1, 1, 1, 1, 1, 1, 3, 3
6	1.0	1.0	2.0	1.0	3.0	4, 4
7	2.0	1.0	2.0	1.0	3.0	4, 4
8	1.0	1.0	1.0	1.0	2.0	
9	1.0	1.0	1.0	1.0	2.0	
10	2.0	1.0	2.0	1.0	3.0	4
11	1.0	1.0	2.0	1.0	3.0	4, 8, 6, 5
12	1.0	1.0	1.0	1.0	2.0	
13	2.0	1.0	2.0	1.0	3.0	4, 4, 4
14	1.0	1.0	2.0	1.0	3.0	4, 4, 4, 4, 8
15	1.0	1.0	2.0	1.0	3.0	4
Av	1.0	1.0	2.0	1.0	3.0	4, 48, 40, 8, 4, 4, 4, 5, 4, 4, 4, 4, 4, 4, 5, 5, 5, 4, 4, 4, 4, 4, 4, 4, 8, 6, 5, 4, 4, 4, 4, 4, 4, 4, 8, 4

Figure a6.30. ***Ls Xp*** **Kb O**

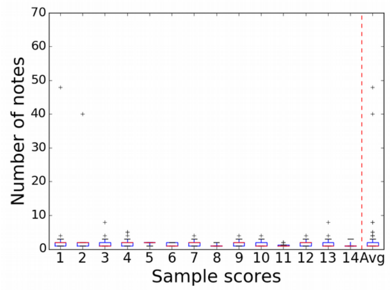

Table a6.30. ***Ls Xp*** **Kb O**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	2.0	1.0	2.0	1.0	3.0	4, 48
2	2.0	1.0	2.0	1.0	2.0	40
3	1.0	1.0	2.0	1.0	3.0	8, 4
4	2.0	1.0	2.0	1.0	3.0	5, 4, 5
5	2.0	2.0	2.0	1.0	2.0	
6	1.0	1.0	2.0	1.0	2.0	
7	2.0	1.0	2.0	1.0	3.0	4
8	1.0	1.0	1.0	1.0	2.0	
9	2.0	1.0	2.0	1.0	3.0	4
10	1.0	1.0	2.0	1.0	3.0	4
11	1.0	1.0	1.25	1.0	1.25	2, 2, 2, 2, 2
12	2.0	1.0	2.0	1.0	3.0	4
13	1.0	1.0	2.0	1.0	3.0	4, 8
14	1.0	1.0	1.0	1.0	3.0	
Av	1.0	1.0	2.0	1.0	3.0	4, 48, 40, 8, 4, 5, 4, 5, 4, 4, 4, 4, 4, 8

Figure a6.31. *Ls Xp* Kb C

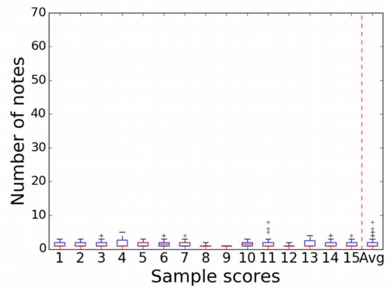

Table a6.31. *Ls Xp* Kb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	2.0	1.0	3.0	
2	1.0	1.0	2.0	1.0	3.0	
3	1.0	1.0	2.0	1.0	3.0	4, 4
4	1.0	1.0	2.75	1.0	5.0	
5	2.0	1.0	2.0	1.0	3.0	
6	1.5	1.0	2.0	1.0	3.0	4, 4
7	2.0	1.0	2.0	1.0	3.0	4
8	1.0	1.0	1.0	1.0	2.0	
9	1.0	1.0	1.0	1.0	1.0	
10	1.5	1.0	2.0	1.0	3.0	
11	1.0	1.0	2.0	1.0	3.0	8, 6, 5
12	1.0	1.0	1.0	1.0	2.0	
13	1.0	1.0	2.5	1.0	4.0	
14	1.0	1.0	2.0	1.0	3.0	4, 4, 4
15	1.0	1.0	2.0	1.0	3.0	4
Av	1.0	1.0	2.0	1.0	3.0	4, 4, 4, 4, 4, 4, 4, 5, 5, 4, 4, 4, 4, 8, 6, 5, 4, 4, 4, 4, 4, 4

Figure a6.32. *Da Xp* Kb

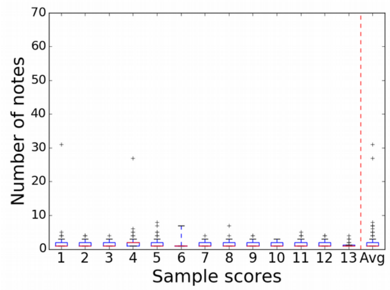

Table a6.32. *Da Xp* Kb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	2.0	1.0	3.0	4, 4, 4, 4, 4, 4, 4, 4, 31, 4, 4, 5
2	1.0	1.0	2.0	1.0	3.0	4, 4, 4, 4, 4
3	1.0	1.0	2.0	1.0	3.0	4
4	2.0	1.0	2.0	1.0	3.0	4, 4, 6, 4, 4, 4, 5, 27, 4, 4, 5
5	1.0	1.0	2.0	1.0	3.0	4, 8, 4, 4, 5, 4, 4, 5, 7, 4
6	1.0	1.0	1.0	1.0	7.0	
7	1.0	1.0	2.0	1.0	3.0	4
8	1.0	1.0	2.0	1.0	3.0	4, 7
9	1.0	1.0	2.0	1.0	3.0	4, 4
10	1.0	1.0	2.0	1.0	3.0	
11	1.0	1.0	2.0	1.0	3.0	4, 5, 4, 4, 4, 4, 4
12	1.0	1.0	2.0	1.0	3.0	4, 4, 4
13	1.0	1.0	1.25	1.0	1.25	2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 4, 3, 2, 3, 2, 3, 2, 2
Av	1.0	1.0	2.0	1.0	3.0	4, 4, 4, 4, 4, 4, 4, 4, 31, 4, 4, 5, 4, 4, 4, 4, 4, 4, 4, 6, 4, 4, 4, 5, 27, 4, 4, 5, 4, 8, 4, 4, 5, 4, 4, 5, 7, 4, 5, 7, 5, 7, 4, 4, 7, 4, 4, 4, 5, 4, 4, 4, 4, 4, 4, 4, 4, 4

Figure a6.33. ***Da Xp*** **Kb O**

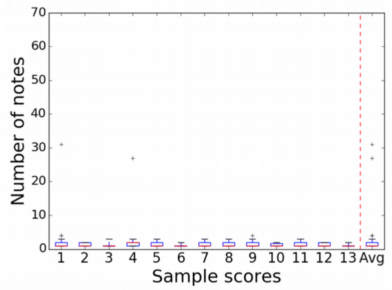

Table a6.33. ***Da Xp*** **Kb O**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	2.0	1.0	3.0	4, 4, 31
2	1.0	1.0	2.0	1.0	2.0	
3	1.0	1.0	1.0	1.0	3.0	
4	2.0	1.0	2.0	1.0	3.0	27
5	1.0	1.0	2.0	1.0	3.0	
6	1.0	1.0	1.0	1.0	2.0	
7	1.0	1.0	2.0	1.0	3.0	
8	1.0	1.0	2.0	1.0	3.0	
9	1.0	1.0	2.0	1.0	3.0	4
10	1.0	1.0	1.75	1.0	2.0	
11	1.0	1.0	2.0	1.0	3.0	
12	1.0	1.0	2.0	1.0	2.0	
13	1.0	1.0	1.0	1.0	2.0	
Av	1.0	1.0	2.0	1.0	3.0	4, 4, 31, 27, 4

Figure a6.34. ***Da Xp*** **Kb C**

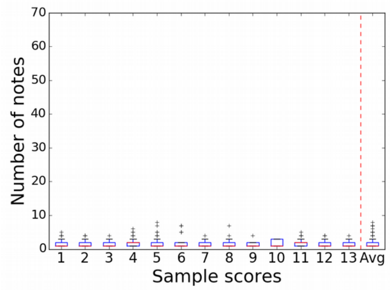

Table a6.34. ***Da Xp*** **Kb C**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	2.0	1.0	3.0	4, 4, 4, 4, 4, 4, 4, 4, 5
2	1.0	1.0	2.0	1.0	3.0	4, 4, 4, 4, 4
3	1.0	1.0	2.0	1.0	3.0	4
4	2.0	1.0	2.0	1.0	3.0	4, 4, 6, 4, 4, 4, 5, 4, 4, 5
5	1.0	1.0	2.0	1.0	3.0	4, 8, 4, 4, 5, 4, 4, 5, 7, 4
6	1.0	1.0	2.0	1.0	2.0	5, 7, 5, 7
7	1.0	1.0	2.0	1.0	3.0	4
8	1.0	1.0	2.0	1.0	3.0	4, 7
9	1.0	1.0	2.0	1.0	2.0	4
10	1.0	1.0	3.0	1.0	3.0	
11	2.0	1.0	2.0	1.0	3.0	4, 5, 4, 4, 4, 4, 4
12	1.0	1.0	2.0	1.0	3.0	4, 4, 4
13	1.0	1.0	2.0	1.0	3.0	4
Av	1.0	1.0	2.0	1.0	3.0	4, 4, 4, 4, 4, 4, 4, 4, 5, 4, 4, 4, 4, 4, 4, 4, 4, 6, 4, 4, 4, 5, 4, 4, 5, 4, 8, 4, 4, 5, 4, 4, 5, 7, 4, 5, 7, 5, 7, 4, 4, 7, 4, 4, 5, 4, 4, 4, 4, 4, 4, 4, 4, 4

a7. Melodic density as duration

The abbreviations used in the headings of the tables contained in this section stand for the following concepts:

- In. Index of the sample score, as it appears in the related plot
- M. Median
- Q1 First Quartile
- Q3 Third Quartile
- L.f. Lower Fence
- U.f. Upper Fence

Figure a7.1. *Ls Eh* Yb

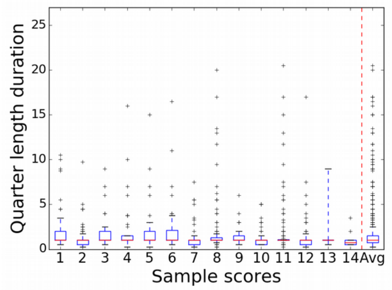

Table a7.1. *Ls Eh* Yb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	2.0	0.5	3.5	4.5, 9.0, 4.5, 10.0, 10.5, 5.5, 8.75
2	1.0	0.5	1.0	0.25	1.75	2.5, 4.5, 2.0, 2.0, 2.5, 2.5, 4.5, 2.0, 2.75, 2.25, 2.0, 2.0, 5.0, 2.5, 4.5, 2.0, 9.75
3	1.0	1.0	2.0	0.5	2.5	4.0, 9.0, 7.0, 6.0, 4.0
4	1.0	1.0	1.5	0.25	1.5	3.75, 10.0, 2.75, 2.5, 3.75, 16.0, 3.75, 6.0, 7.0
5	1.0	1.0	2.0	0.25	3.0	9.0, 15.0, 3.75, 6.0, 7.0
6	1.0	1.0	2125	0.5	3.75	4.0, 11.0, 4.0, 16.5, 6.0, 7.0
7	1.0	0.5	1.0	0.25	1.5	3.5, 5.0, 7.5, 2.75, 5.5, 2.0, 5.5, 3.25
8	1.0	1.0	1.3125	0.75	1.75	0.25, 0.5, 0.25, 0.5, 0.5, 0.5, 0.5, 0.5, 0.25, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.25, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5,

						0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.25, 0.5, 0.5, 0.5, 4.0, 13.5, 7.0, 2.0, 2.0, 3.0, 4.5, 2.0, 13.0, 2.5, 6.25, 2.0, 20.0, 2.0, 2.0, 2.0, 2.0, 17.0, 11.75, 9.5, 5.5, 3.0, 2.0, 4.0, 2.0, 5.5, 5.5
9	1.0	1.0	1.5	0.5	2.0	6.0, 3.0, 3.0, 4.0, 3.0
10	1.0	0.5	1.0	0.5	1.5	3.0, 5.0, 2.5, 3.0, 3.0, 2.0, 5.0, 3.5, 2.0, 5.0
11	1.0	1.0	1.0625	1.0	1.0625	0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.25, 0.75, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 1.5, 4.0, 2.0, 2.0, 15.0, 7.0, 2.0, 2.0, 1.5, 2.0, 2.0, 1.5, 2.0, 1.25, 1.5, 3.0, 4.5, 2.0, 13.0, 2.5, 6.0, 2.0, 20.5, 2.0, 2.0, 2.0, 2.0, 17.0, 11.75, 9.5, 5.5, 1.5, 3.25, 2.0, 2.0, 2.0, 4.0, 2.0, 7.5, 5.5
12	1.0	0.5	1.0	0.25	1.75	3.0, 3.5, 3.0, 2.0, 4.0, 7.5, 6.0, 2.0, 2.0, 5.0, 3.0, 17.0
13	1.0	1.0	1.0	0.5	9.0	
14	0.75	0.5	1.0	0.5	1.0	3.5, 2.0
Av	1.0	0.75	1.5	0.25	2.5	4.5, 9.0, 3.0, 3.5, 2.75, 4.5, 10.0, 3.0, 10.5, 5.5, 8.75, 4.5, 4.5, 2.75, 5.0, 4.5, 9.75, 4.0, 9.0, 7.0, 6.0, 4.0, 3.75, 10.0, 2.75, 3.75, 16.0, 3.75, 6.0, 7.0, 3.0, 9.0, 3.0, 3.0, 15.0, 3.75, 6.0, 7.0, 4.0, 11.0, 3.0, 4.0, 16.5, 3.75, 6.0, 7.0, 3.5, 5.0, 7.5, 2.75, 5.5, 5.5, 3.25, 4.0, 13.5, 7.0, 3.0, 4.5, 13.0, 6.25, 20.0, 17.0, 11.75, 9.5, 5.5, 3.0, 4.0, 5.5, 5.5, 6.0, 3.0, 3.0, 4.0, 3.0, 3.0, 5.0, 3.0, 3.0, 5.0, 3.5, 5.0, 4.0, 15.0, 7.0, 3.0, 4.5, 13.0, 6.0, 20.5, 17.0, 11.75, 9.5, 5.5, 3.25, 4.0, 7.5, 5.5, 3.0, 3.5, 3.0, 4.0, 7.5, 6.0, 5.0, 3.0, 17.0, 3.0, 3.0, 9.0, 4.0, 3.5

Figure a7.2. ***Ls Eh*** **Yb O1**

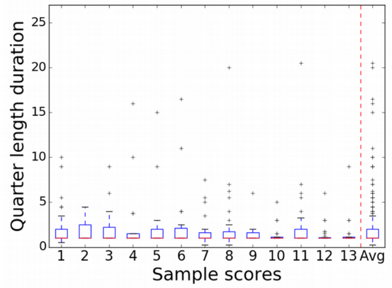

Table a7.2. ***Ls Eh*** **Yb O1**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	2.0	0.5	3.5	4.5, 9.0, 4.5, 10.0, 5.5
2	1.0	1.0	2.5	1.0	4.5	
3	1.0	1.0	2.25	1.0	4.0	9.0, 6.0
4	1.0	1.0	1.5	1.0	1.5	3.75, 10.0, 3.75, 16.0
5	1.0	1.0	2.0	1.0	3.0	9.0, 15.0
6	1.0	1.0	2125	1.0	2.5	4.0, 11.0, 4.0, 16.5
7	1.0	1.0	1625	0.25	2.0	3.5, 5.0, 7.5, 5.5
8	1.0	1.0	1.75	0.25	2.5	4.0, 7.0, 6.25, 20.0, 5.5, 3.0
9	1.0	1.0	1625	1.0	2.0	6.0
10	1.0	1.0	1125	1.0	1125	1.5, 3.0, 5.0, 1.5, 3.0
11	1.0	1.0	2.0	1.0	3.25	4.0, 7.0, 6.0, 20.5, 5.5
12	1.0	1.0	1.0625	1.0	1.0625	3.0, 1.25, 1.75, 3.0, 1.5, 6.0, 1.75
13	1.0	1.0	1125	1.0	1125	1.5, 3.0, 1.5, 3.0, 9.0
Av	1.0	1.0	2.0	0.25	3.5	4.5, 9.0, 4.5, 10.0, 5.5, 4.5, 4.5, 4.5, 4.0, 9.0, 6.0, 3.75, 10.0, 3.75, 16.0, 9.0, 15.0, 4.0, 11.0, 4.0, 16.5, 5.0, 7.5, 5.5, 4.0, 7.0, 6.25, 20.0, 5.5, 6.0, 5.0, 4.0, 7.0, 6.0, 20.5, 5.5, 6.0, 9.0

Figure a7.3. *Ls Eh* Yb O2

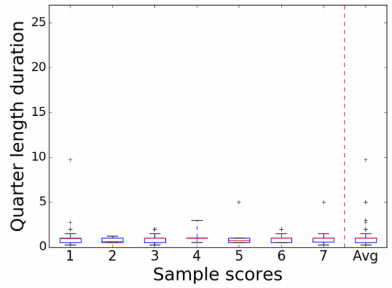

Table a7.3. *Ls Eh* Yb O2

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	0.9375	0.5	1.0	0.25	1.5	2.0, 2.75, 2.0, 2.0, 9.75
2	625	0.5	1.0	0.5	1.25	
3	1.0	0.5	1.0	0.25	1.5	2.0, 2.0, 2.0, 2.0
4	1.0	1.0	1.0	0.5	3.0	
5	0.75	0.5	1.0	0.5	1.0	5.0
6	1.0	0.5	1.0	0.5	1.5	2.0, 2.0, 2.0, 2.0, 2.0
7	1.0	0.5625	1.0	0.25	1.5	5.0
Av	1.0	0.5	1.0	0.25	1.5	2.0, 2.75, 2.0, 2.0, 9.75, 2.0, 2.0, 2.0, 2.0, 3.0, 3.0, 5.0, 2.0, 2.0, 2.0, 2.0, 2.0, 5.0

Figure a7.4. *Ls Eh* Yb C

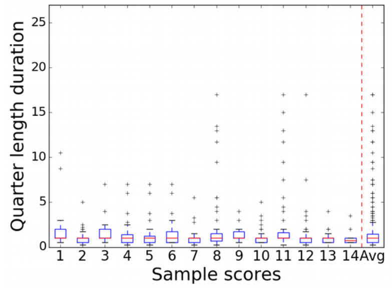

Table a7.4. *Ls Eh* Yb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	2.0	0.5	3.0	10.5, 8.75
2	1.0	0.5	1.0	0.25	1.75	2.0, 2.5, 2.25, 2.0, 5.0
3	1.0	1.0	2.0	0.5	2.5	7.0, 4.0
4	1.0	0.5	1375	0.25	2.5	2.75, 3.75, 6.0, 7.0
5	1.0	0.5	1.25	0.25	2.0	3.0, 3.75, 6.0, 7.0
6	1.0	0.5	1.75	0.5	3.0	3.75, 6.0, 7.0
7	1.0	0.5	1.0	0.25	1.5	2.75, 5.5, 3.25
8	1.0	0.6875	1.5	0.25	2.0	13.5, 3.0, 4.5, 13.0, 17.0, 11.75, 9.5, 4.0, 5.5, 5.5
9	1.0	1.0	1.75	0.5	2.0	4.0, 3.0
10	1.0	0.5	1.0	0.5	1.5	2.5, 3.0, 2.0, 3.5, 2.0, 5.0
11	1.0	1.0	1625	0.25	2.0	15.0, 3.0, 4.5, 13.0, 17.0, 11.75, 9.5, 4.0, 7.5, 5.5
12	1.0	0.5	1.0	0.25	1.75	3.5, 2.0, 4.0, 7.5, 2.0, 2.0, 3.0, 17.0
13	1.0	0.5	1.0	0.5	1.5	2.0, 4.0, 2.0
14	0.75	0.5	1.0	0.5	1.0	3.5, 2.0
Av	1.0	0.5	1.4375	0.25	2.75	3.0, 3.0, 10.5, 8.75, 5.0, 7.0, 4.0, 3.75, 6.0, 7.0, 3.0, 3.75, 6.0, 7.0, 3.0, 3.75, 6.0, 7.0, 5.5, 3.25, 13.5, 3.0, 4.5, 13.0, 17.0, 11.75, 9.5, 4.0, 5.5, 5.5, 4.0, 3.0, 3.0, 3.5, 5.0, 15.0, 3.0, 4.5, 13.0, 17.0, 11.75, 9.5, 4.0, 7.5, 5.5, 3.5, 4.0, 7.5, 3.0, 17.0, 4.0, 3.5

Figure a7.5. *Ls Xp* Yb

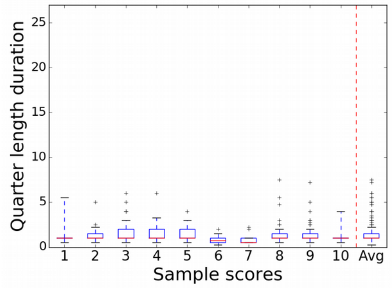

Table a7.5. *Ls Xp* Yb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	1.0	0.5	5.5	
2	1.0	1.0	1.5	0.5	2.25	2.5, 5.0
3	1.0	1.0	2.0	0.5	3.0	5.0, 4.0, 4.0, 4.0, 4.0, 6.0
4	1.0	1.0	2.0	0.5	3.25	6.0
5	1.0	1.0	2.0	0.5	3.0	4.0
6	0.75	0.5	1.0	0.25	1.5	2.0
7	0.5	0.5	1.0	0.5	1.0	2.0, 2.25
8	1.0	1.0	1.5	0.5	2.0	2.5, 5.5, 2.5, 4.75, 7.5, 3.0
9	1.0	1.0	1.5	0.5	2.0	3.0, 7.25, 2.5, 3.0, 2.75, 2.5, 5.0, 4.0
10	1.0	1.0	1.0	0.5	4.0	
Av	1.0	1.0	1.5	0.25	2.25	5.5, 3.0, 4.75, 3.0, 3.5, 2.5, 5.0, 5.0, 3.0, 4.0, 4.0, 4.0, 4.0, 2.5, 6.0, 2.5, 3.25, 3.0, 3.0, 6.0, 3.0, 3.0, 2.5, 3.0, 2.5, 4.0, 2.5, 5.5, 2.5, 4.75, 7.5, 3.0, 3.0, 7.25, 2.5, 3.0, 2.75, 2.5, 5.0, 4.0, 2.5, 2.5, 2.5, 3.0, 4.0

Figure a7.6. *Ls Xp* Yb O

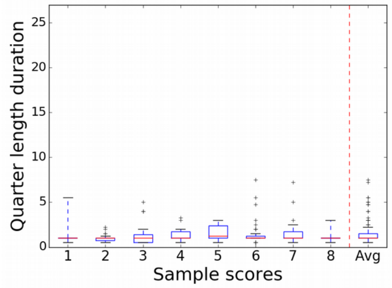

Table a7.6. *Ls Xp* Yb O

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	1.0	0.5	5.5	
2	1.0	0.75	1.0	0.5	1.25	2.0, 2.25, 1.5, 1.5
3	1.0	0.5	1375	0.5	2.0	5.0, 4.0, 4.0
4	1.0	1.0	1.75	0.5	2.0	3.25, 3.0
5	1.25	1.0	2375	0.5	3.0	
6	1.0	1.0	1.25	1.0	1.5	0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 2.0, 2.5, 5.5, 2.0, 4.75, 2.0, 7.5, 3.0
7	1.0	1.0	1.75	0.5	2.5	7.25, 3.0, 5.0
8	1.0	1.0	1.0	0.5	3.0	
Av	1.0	1.0	1.5	0.5	2.25	5.5, 4.75, 5.0, 4.0, 4.0, 3.25, 3.0, 3.0, 3.0, 2.5, 3.0, 2.5, 5.5, 4.75, 7.5, 3.0, 7.25, 2.5, 3.0, 2.5, 5.0, 3.0

Figure a7.7. *Ls Xp* Yb C

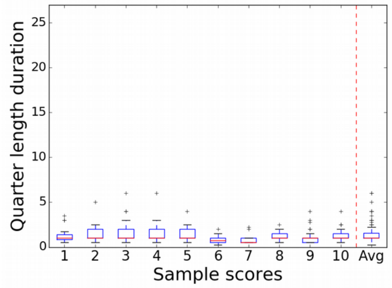

Table a7.7. *Ls Xp* Yb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	875	1375	0.5	1.75	3.0, 3.0, 3.5
2	1.0	1.0	2.0	0.5	2.5	5.0
3	1.0	1.0	2.0	0.5	3.0	4.0, 4.0, 6.0
4	1.0	1.0	2.0	0.5	3.0	6.0
5	1.0	1.0	2.0	0.5	2.5	4.0
6	0.75	0.5	1.0	0.25	1.5	2.0
7	0.5	0.5	1.0	0.5	1.0	2.0, 2.25
8	1.0	1.0	1.5	0.5	2.0	2.5
9	1.0	0.5	1.0	0.5	1.5	3.0, 2.0, 2.75, 2.0, 4.0
10	1.0	1.0	1.5	0.5	2.0	2.5, 2.5, 2.5, 4.0
Av	1.0	1.0	1.5625	0.25	2.25	3.0, 3.0, 3.5, 2.5, 5.0, 3.0, 4.0, 4.0, 2.5, 6.0, 2.5, 3.0, 6.0, 2.5, 4.0, 2.5, 3.0, 2.75, 4.0, 2.5, 2.5, 2.5, 4.0

Figure a7.8. ***Da Eh*** **Yb**

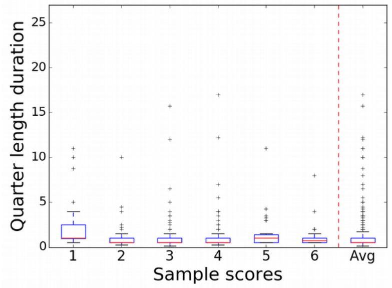

Figure a7.9. ***Da Eh*** **Yb O1**

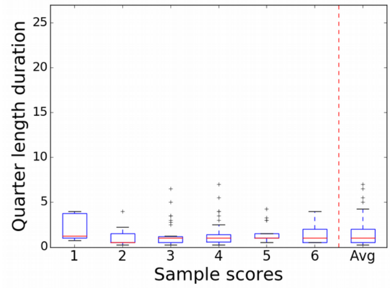

Table a7.8. ***Da Eh*** **Yb**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	0.9375	2.5	0.5	4.0	5.0, 8.75, 11.0, 10.0
2	0.5	0.5	1.0	0.25	1.5	4.0, 2.25, 2.0, 4.5, 2.5, 10.0
3	0.5	0.5	1.0	125	1.5	2.75, 3.5, 2.0, 12.0, 2.5, 6.5, 3.0, 5.0, 4.0, 2.0, 15.75, 3.5, 2.0
4	0.5	0.5	1.0	0.25	1.5	3.5, 4.0, 2.5, 12.25, 2.5, 7.0, 3.0, 5.5, 2.0, 4.0, 2.0, 17.0, 4.0, 2.0, 2.0
5	1.0	0.5	1375	0.5	1.5	3.0, 4.25, 11.0, 3.25, 3.0, 3.5
6	0.75	0.5	1.0	0.5	1.5	2.0, 4.0, 2.0, 2.0, 8.0
Av	0.5	0.5	1.0	125	1.75	4.0, 4.0, 2.5, 2.5, 3.0, 5.0, 8.75, 4.0, 4.0, 3.0, 2.0, 3.0, 11.0, 3.5, 3.0, 10.0, 4.0, 2.25, 2.0, 4.5, 2.5, 10.0, 2.75, 3.5, 2.0, 12.0, 2.5, 6.5, 3.0, 5.0, 4.0, 2.0, 15.75, 3.5, 2.0, 3.5, 4.0, 2.5, 12.25, 2.5, 7.0, 3.0, 5.5, 2.0, 4.0, 2.0, 17.0, 4.0, 2.0, 2.0, 3.0, 4.25, 11.0, 3.25, 3.0, 3.5, 2.0, 4.0, 2.0, 2.0, 8.0

Table a7.9. ***Da Eh*** **Yb O1**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.25	1.0	3.75	0.75	4.0	
2	0.5	0.5	1.5	0.25	2.25	4.0
3	1.0	0.5	1.1875	0.25	1.25	2.75, 3.5, 2.5, 6.5, 3.0, 5.0, 3.5
4	1.0	0.5625	1375	0.25	2.5	3.5, 4.0, 7.0, 3.0, 5.5, 4.0
5	1.0	1.0	1.5	0.5	1.5	3.0, 4.25, 3.25, 3.0
6	1.0	0.5	2.0	0.5	4.0	
Av	1.0	0.5	2.0	0.25	4.25	6.5, 5.0, 7.0, 5.5

Figure a7.10. *Da Eh* Yb O2

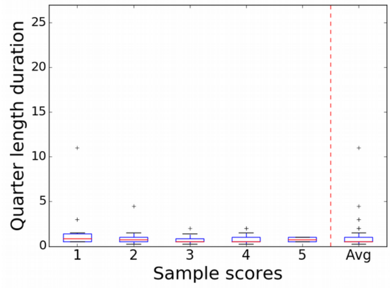

Figure a7.11. *Da Eh* Yb C

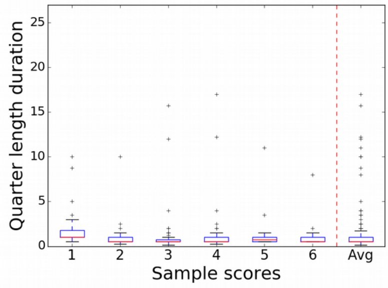

Table a7.10. *Da Eh* Yb O2

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	875	0.5	1375	0.5	1.5	3.0, 3.0, 11.0
2	0.75	0.5	1.0	0.25	1.5	4.5
3	0.5	0.5	875	0.25	1375	2.0
4	0.5	0.5	1.0	0.25	1.5	2.0, 2.0
5	0.75	0.5	1.0	0.5	1.0	
Av	0.5	0.5	1.0	0.25	1.5	3.0, 3.0, 11.0, 4.5, 2.0, 2.0, 2.0

Table a7.11. *Da Eh* Yb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	1.8125	0.5	3.0	5.0, 8.75, 3.5, 10.0
2	0.5	0.5	1.0	0.25	1.5	2.0, 2.5, 10.0
3	0.5	0.5	0.75	125	1.0	1.5, 2.0, 12.0, 1.5, 4.0, 1.5, 1.5, 15.75, 1.25, 2.0
4	0.5	0.5	1.0	0.25	1.5	2.5, 12.25, 4.0, 17.0, 2.0, 2.0
5	0.75	0.5	1.0	0.5	1.5	11.0, 3.5
6	0.5	0.5	1.0	0.5	1.5	2.0, 8.0
Av	0.5	0.5	1.0	125	1.75	2.5, 5.0, 8.75, 2.0, 3.5, 3.0, 10.0, 2.0, 2.5, 10.0, 2.0, 12.0, 4.0, 15.75, 2.0, 2.5, 12.25, 4.0, 17.0, 2.0, 2.0, 11.0, 3.5, 2.0, 8.0

Figure a7.12. ***Da Xp*** **Yb**

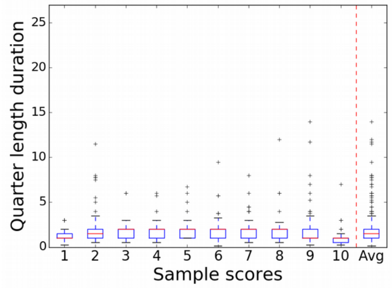

Table a7.12. ***Da Xp*** **Yb**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	1.5	0.25	2.0	3.0, 3.0, 3.0, 3.0
2	1.5	1.0	2.0	0.5	3.5	7.75, 7.75, 4.0, 11.5, 5.5, 8.0, 7.5, 5.0
3	2.0	1.0	2.0	0.5	3.0	6.0, 6.0
4	2.0	1.0	2.0	0.5	3.0	5.75, 4.0, 6.0
5	2.0	1.0	2.0	1.0	3.0	6.75, 6.0, 4.0, 5.0
6	2.0	1.0	2.0	125	3.25	9.5, 3.75, 5.75, 5.75, 3.75, 3.75
7	2.0	1.0	2.0	0.5	3.0	8.0, 4.0, 4.5, 6.0, 4.0, 4.5, 4.0
8	2.0	1.0	2.0	0.5	2.75	12.0, 6.0, 4.0, 6.0
9	1.0	1.0	2.0	0.25	3.5	5.25, 14.0, 8.0, 7.0, 11.75, 3.75, 4.0, 6.0, 4.0
10	1.0	0.5	1.0	0.25	1.5	2.0, 3.0, 3.0, 7.0, 2.0
Av	1.5	1.0	2.0	125	3.5	7.75, 7.75, 4.0, 11.5, 5.5, 8.0, 7.5, 5.0, 6.0, 6.0, 5.75, 4.0, 6.0, 6.75, 6.0, 4.0, 5.0, 9.5, 3.75, 5.75, 5.75, 3.75, 3.75, 8.0, 4.0, 4.5, 6.0, 4.0, 4.5, 4.0, 12.0, 6.0, 4.0, 6.0, 5.25, 14.0, 8.0, 7.0, 11.75, 3.75, 4.0, 6.0, 4.0, 7.0

Figure a7.13. ***Da Xp*** **Yb O**

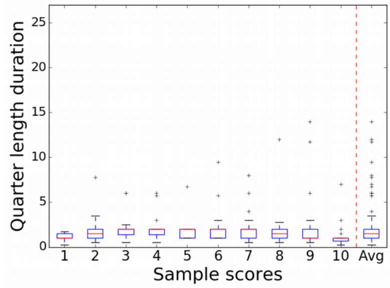

Table a7.13. ***Da Xp*** **Yb O**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	1.5	0.25	1.75	
2	1.5	1.0	2.0	0.5	3.5	7.75
3	2.0	1375	2.0	0.5	2.5	6.0, 6.0
4	2.0	1375	2.0	0.5	2.0	3.0, 5.75, 6.0
5	2.0	1.0	2.0	1.0	2.0	6.75
6	2.0	1.0	2.0	1.0	3.0	9.5, 5.75
7	2.0	1.0	2.0	0.5	3.0	8.0, 6.0, 4.0
8	1.5	1.0	2.0	0.5	2.75	12.0
9	1.0	1.0	2.0	0.5	3.0	14.0, 11.75, 6.0
10	1.0	0.6875	1.0	0.25	1.0	2.0, 3.0, 1.5, 7.0
Av	1.5	1.0	2.0	0.25	3.5	7.75, 6.0, 6.0, 5.75, 6.0, 6.75, 9.5, 5.75, 8.0, 6.0, 4.0, 12.0, 14.0, 11.75, 6.0, 7.0

Figure a7.14. *Da Xp* Yb C

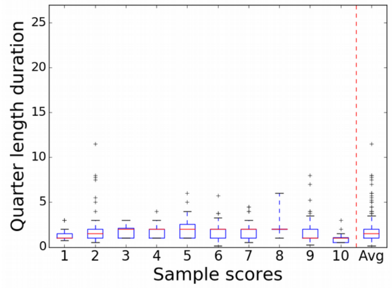

Table a7.14. *Da Xp* Yb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	1.5	0.75	2.0	3.0, 3.0, 3.0, 3.0
2	1.5	1.0	2.0	0.5	3.0	7.75, 4.0, 11.5, 5.5, 8.0, 7.5, 5.0
3	2.0	1.0	2125	1.0	3.0	
4	2.0	1.0	2.0	1.0	3.0	4.0
5	2.0	1.0	2.5625	1.0	4.0	6.0, 5.0
6	2.0	1.0	2.0	125	3.25	3.75, 5.75, 3.75, 3.75
7	2.0	1.0	2.0	0.5	3.0	4.0, 4.5, 4.0, 4.5
8	2.0	2.0	2.0	1.0	6.0	
9	1.0	1.0	2.0	0.25	3.5	5.25, 8.0, 7.0, 3.75, 4.0, 4.0
10	1.0	0.5	1.0625	0.5	1.5	3.0, 2.0
Av	1.5	1.0	2.0	125	3.5	7.75, 4.0, 11.5, 5.5, 8.0, 7.5, 5.0, 4.0, 6.0, 4.0, 5.0, 3.75, 5.75, 3.75, 3.75, 4.0, 4.5, 4.0, 4.5, 6.0, 4.0, 6.0, 5.25, 8.0, 7.0, 3.75, 4.0, 4.0

Figure a7.15. *Ls Eh* Mb

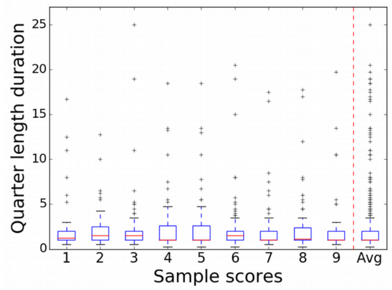

Table a7.15. *Ls Eh* Mb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.25	1.0	2.0	0.5	3.0	6.0, 16.75, 5.25, 12.5, 8.0, 11.0
2	1.5	1.0	2.5	0.5	4.25	6.5, 12.75, 5.75, 10.0, 5.5, 6.25
3	1.5	1.0	2.0	0.5	3.5	4.0, 19.0, 5.25, 11.0, 6.5, 5.0, 5.0, 4.0, 4.5, 25.0
4	1.0	1.0	2625	0.25	4.75	7.5, 18.5, 5.25, 13.5, 6.75, 13.25, 5.5, 10.5
5	1.0	1.0	2625	0.25	4.75	7.75, 18.5, 5.5, 13.5, 6.75, 13.0, 5.5, 10.5
6	1.5	1.0	2.0	0.25	3.5	4.0, 8.0, 19.0, 5.750000000000001, 4.25, 15.0, 5.0, 4.5, 3.75, 3.75, 5.25, 8.0, 20.5
7	1.0	1.0	2.0	0.5	3.5	7.5, 4.0, 17.5, 4.5, 8.5, 4.5, 6.0, 6.5, 16.5
8	1125	1.0	2375	0.25	3.5	8.0, 17.75, 6.0, 5.25, 12.0, 5.5, 4.5, 4.5, 4.5, 6.0, 7.75, 17.0
9	1.0	1.0	2.0	0.5	3.0	5.5, 10.5, 13.5, 5.0, 10.5, 5.0, 19.75
Av	1.0	1.0	2.0	0.25	3.5	6.0, 16.75, 5.25, 12.5, 8.0, 11.0, 6.5, 12.75, 4.25, 5.75, 10.0, 5.5, 6.25, 4.0, 19.0, 5.25, 11.0, 6.5, 5.0, 5.0, 4.0, 4.5, 25.0, 7.5, 4.0, 18.5, 5.25, 3.75, 13.5, 6.75, 4.0, 4.75, 4.0, 13.25, 5.5, 10.5, 7.75, 4.0, 18.5, 5.5, 3.75, 13.5, 6.75, 4.0, 4.75, 4.0, 13.0, 5.5, 10.5, 4.0, 8.0, 19.0, 5.750000000000001, 4.25, 15.0, 5.0, 4.5, 3.75, 3.75, 5.25, 8.0, 20.5, 7.5, 4.0, 17.5, 4.5, 8.5, 4.5, 6.0, 6.5, 16.5, 8.0, 17.75, 6.0, 5.25, 12.0, 5.5, 4.5, 4.5, 4.5, 6.0, 7.75, 17.0, 5.5, 10.5, 13.5, 5.0, 10.5, 5.0, 19.75

Figure a7.16. *Ls Eh* Mb O1

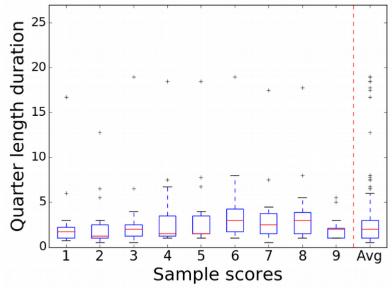

Table a7.16. *Ls Eh* Mb O1

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.75	1.0	2.25	0.75	3.0	6.0, 16.75
2	1.25	1.0	2.5	0.5	3.0	6.5, 12.75, 5.5
3	2.0	1.25	2.5	0.5	4.0	19.0, 6.5
4	1.5	1.25	3.5	1.0	6.75	7.5, 18.5
5	1.5	1.5	3.5	1.0	4.0	7.75, 18.5, 6.75
6	3.0	1.75	4.25	1.0	8.0	19.0
7	2.5	1.5	3.75	0.5	4.5	7.5, 17.5
8	3.0	1.5	3875	1.0	5.5	8.0, 17.75
9	2.0	1.0	2125	1.0	3.0	5.5, 5.0
Av	2.0	1.0	3.0	0.5	6.0	16.75, 6.5, 12.75, 19.0, 6.5, 7.5, 18.5, 6.75, 7.75, 18.5, 6.75, 8.0, 19.0, 7.5, 17.5, 8.0, 17.75

Figure a7.17. *Ls Eh* Mb O2

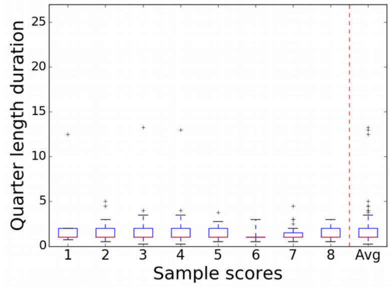

Table a7.17. *Ls Eh* Mb O2

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	2.0	0.75	2.0	12.5
2	1.0	1.0	2.0	0.5	3.0	5.0, 4.5
3	1.0	1.0	2.0	0.25	3.5	4.0, 13.25
4	1.0	1.0	2.0	0.25	3.5	4.0, 13.0
5	1.0	1.0	2.0	0.5	2.75	3.75
6	1.0	1.0	1.0	0.5	3.0	
7	1.0	1.0	1.5	0.5	2.0	4.5, 3.0, 2.5, 3.0, 3.0
8	1.0	1.0	2.0	0.5	3.0	
Av	1.0	1.0	2.0	0.25	3.5	12.5, 5.0, 4.5, 4.0, 13.25, 4.0, 13.0, 3.75, 4.5

Figure a7.18. *Ls Eh* Mb C

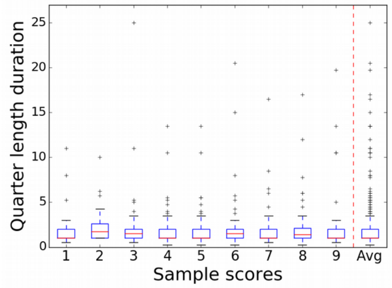

Table a7.18. *Ls Eh* Mb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	2.0	0.5	3.0	5.25, 8.0, 11.0
2	1.75	1.0	2625	1.0	4.25	5.75, 10.0, 6.25
3	1.5	1.0	2.0	0.5	3.5	5.25, 11.0, 5.0, 4.0, 25.0
4	1.0	1.0	2.0	0.25	3.5	5.25, 3.75, 13.5, 4.0, 4.75, 5.5, 10.5
5	1.0	1.0	2.0	0.25	3.5	5.5, 3.75, 13.5, 4.0, 4.75, 5.5, 10.5
6	1.5	1.0	2.0	0.25	3.0	5.750000000000001, 4.25, 15.0, 3.75, 5.25, 8.0, 20.5
7	1.0	1.0	2.0	0.5	3.5	4.5, 8.5, 6.0, 6.5, 16.5
8	1375	1.0	2125	0.25	3.5	6.0, 5.25, 12.0, 4.5, 6.0, 7.75, 17.0
9	1.0	1.0	2.0	0.5	3.0	10.5, 13.5, 10.5, 5.0, 19.75
Av	1.0	1.0	2.0	0.25	3.5	5.25, 8.0, 11.0, 4.25, 5.75, 10.0, 6.25, 5.25, 11.0, 5.0, 4.0, 25.0, 5.25, 3.75, 13.5, 4.0, 4.75, 5.5, 10.5, 5.5, 3.75, 13.5, 4.0, 4.75, 5.5, 10.5, 5.750000000000001, 4.25, 15.0, 3.75, 5.25, 8.0, 20.5, 4.5, 8.5, 6.0, 6.5, 16.5, 6.0, 5.25, 12.0, 4.5, 6.0, 7.75, 17.0, 10.5, 13.5, 10.5, 5.0, 19.75

Figure a7.19. *Ls Xp* Mb

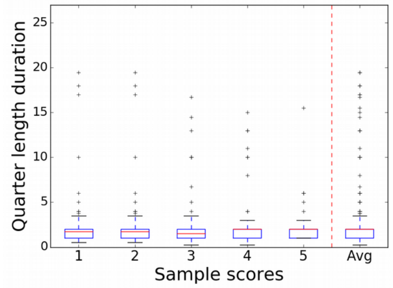

Table a7.19. *Ls Xp* Mb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.75	1.0	2.0	0.5	3.5	10.0, 3.75, 6.0, 4.0, 17.0, 18.0, 5.0, 19.5, 4.0
2	1.75	1.0	2.0	0.5	3.5	10.0, 3.75, 6.0, 4.0, 17.0, 18.0, 5.0, 19.5, 4.0
3	1.5	1.0	2.0	0.25	3.5	5.0, 10.0, 16.75, 6.75, 14.5, 4.0, 10.0, 13.0, 10.0
4	2.0	1.0	2.0	0.25	3.0	4.0, 10.0, 15.0, 8.0, 13.0, 4.0, 10.0, 13.0, 11.0
5	2.0	1.0	2.0	1.0	3.0	6.0, 5.0, 6.0, 15.5, 4.0, 6.0
Av	2.0	1.0	2.0	0.25	3.5	10.0, 3.75, 6.0, 4.0, 17.0, 18.0, 5.0, 19.5, 4.0, 10.0, 3.75, 6.0, 4.0, 17.0, 18.0, 5.0, 19.5, 4.0, 5.0, 10.0, 16.75, 6.75, 14.5, 4.0, 10.0, 13.0, 10.0, 4.0, 10.0, 15.0, 8.0, 13.0, 4.0, 10.0, 13.0, 11.0, 6.0, 5.0, 6.0, 15.5, 4.0, 6.0

Figure a7.20. *Ls Xp* Mb O

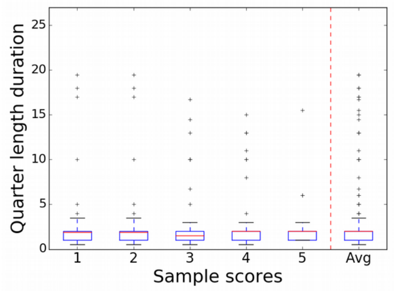

Figure a7.21. *Ls Xp* Mb C

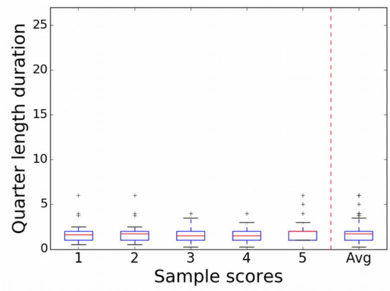

Table a7.20. *Ls Xp* Mb O

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1875	1.0	2.0	0.5	3.5	10.0, 4.0, 17.0, 18.0, 5.0, 19.5
2	1875	1.0	2.0	0.5	3.5	10.0, 4.0, 17.0, 18.0, 5.0, 19.5
3	1.5	1.0	2.0	0.5	3.0	5.0, 10.0, 16.75, 6.75, 14.5, 10.0, 13.0, 10.0
4	2.0	1.0	2.0	0.5	3.0	4.0, 10.0, 15.0, 8.0, 13.0, 10.0, 13.0, 11.0
5	2.0	1.0	2.0	1.0	3.0	6.0, 6.0, 15.5
Av	2.0	1.0	2.0	0.5	3.5	10.0, 4.0, 17.0, 18.0, 5.0, 19.5, 10.0, 4.0, 17.0, 18.0, 5.0, 19.5, 5.0, 10.0, 16.75, 6.75, 14.5, 10.0, 13.0, 10.0, 4.0, 10.0, 15.0, 8.0, 13.0, 10.0, 13.0, 11.0, 6.0, 6.0, 15.5

Table a7.21. *Ls Xp* Mb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1625	1.0	2.0	0.5	2.5	3.75, 6.0, 4.0
2	1.75	1.0	2.0	0.5	2.5	3.75, 6.0, 4.0
3	1.5	1.0	2.0	0.25	3.5	4.0
4	1.5	1.0	2.0	0.25	3.0	4.0
5	2.0	1.0	2.0	1.0	3.0	5.0, 4.0, 6.0
Av	1.75	1.0	2.0	0.25	3.5	3.75, 6.0, 4.0, 3.75, 6.0, 4.0, 4.0, 4.0, 5.0, 4.0, 6.0

Figure a7.22. ***Da Eh*** **Mb**

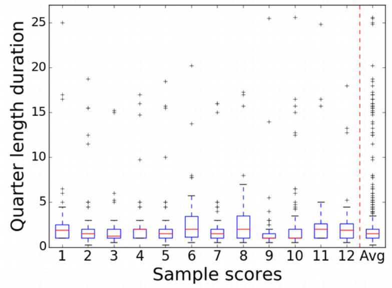

Table a7.22. ***Da Eh*** **Mb**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1875	1.0	2.5	1.0	4.5	6.0, 16.5, 17.0, 6.5, 25.0, 5.0
2	1.5	1.0	2.0	0.25	3.0	5.0, 15.5, 4.5, 12.5, 5.0, 15.5, 4.5, 18.75, 5.0, 11.5
3	1.25	1.0	2.0	0.5	3.0	5.0, 15.0, 5.25, 6.0, 15.25
4	2.0	1.0	2.0	1.0	3.0	5.0, 16.0, 4.5, 17.0, 5.0, 14.75, 4.5, 9.75
5	1.5	1.0	2.0	0.25	3.0	5.0, 15.5, 4.5, 15.75, 5.0, 18.5, 4.5, 10.0
6	2.0	1125	3.4375	0.5	5.75	7.75, 13.75, 7.75, 20.25, 8.0
7	1.5	1.0	2.0	0.5	3.0	5.0, 16.0, 4.5, 16.0, 5.0, 15.0, 4.5, 4.0
8	2.0	1.0	3.5	0.5	7.0	15.75, 17.0, 17.25, 8.0
9	1.0	1.0	1.5	0.5	2.0	2.5, 5.5, 3.0, 3.0, 3.0, 3.0, 3.0, 3.0, 3.0, 4.0, 3.0, 3.0, 14.0, 3.0, 3.0, 3.0, 2.5, 25.5
10	1.0	1.0	2.0	0.5	3.5	4.75, 15.0, 4.25, 15.75, 5.0, 4.5, 25.625, 4.25, 12.5, 6.5, 12.75, 6.5, 6.0, 16.5
11	2.0	1.0	2625	1.0	5.0	15.75, 16.5, 24.875
12	1875	1.0	2625	0.5	4.5	5.25, 12.75, 13.25, 18.0
Av	1.5	1.0	2.0	0.25	3.5	6.0, 16.5, 4.5, 17.0, 6.5, 25.0, 4.5, 5.0, 5.0, 15.5, 4.5, 12.5, 5.0, 15.5, 4.5, 18.75, 5.0, 11.5, 5.0, 15.0, 5.25, 6.0, 15.25, 5.0, 16.0, 4.5, 17.0, 5.0, 14.75, 4.5, 9.75, 5.0, 15.5, 4.5, 15.75, 5.0, 18.5, 4.5, 10.0, 7.75, 4.0, 4.0, 4.0, 13.75, 4.0, 7.75, 3.875, 5.0, 20.25, 5.75, 8.0, 5.0, 16.0, 4.5, 16.0, 5.0, 15.0, 4.5, 4.0, 6.75, 15.75, 5.5, 4.75, 17.0, 3.75, 7.0, 5.0, 3.75, 4.25, 17.25, 5.25, 8.0, 5.5, 4.0, 14.0, 25.5, 4.75, 15.0, 4.25, 15.75, 5.0, 4.5, 25.625, 4.25, 12.5, 6.5, 12.75, 6.5, 6.0, 16.5, 4.75, 15.75, 4.5, 16.5, 5.0, 24.875, 4.5, 5.25, 12.75, 4.5, 13.25, 4.5, 18.0, 4.5

Figure a7.23. ***Da Eh*** **Mb O1**

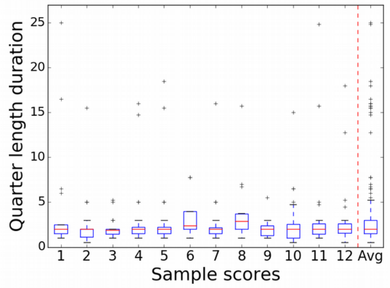

Table a7.23. ***Da Eh*** **Mb O1**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	2.0	1.5	2.5	1.0	2.5	6.0, 16.5, 6.5, 25.0
2	2.0	1125	2.0	0.5	3.0	5.0, 15.5, 5.0, 5.0
3	1875	1.4375	2.0	1.0	2.0	5.0, 3.0, 5.25, 3.0
4	2.0	1.5	2.25	1.0	3.0	5.0, 16.0, 5.0, 14.75
5	2.0	1.5	2.25	1.0	3.0	5.0, 15.5, 5.0, 18.5
6	2375	2.0	4.0	1.0	4.0	7.75, 7.75
7	2.0	1.5	2.1875	1.0	3.0	5.0, 16.0, 5.0
8	2875	2.0	3.6875	1.0	3.75	6.75, 15.75, 7.0
9	2.0	1.3125	2375	1.0	3.0	5.5
10	2.0	1.0	2.5625	0.5	4.75	15.0, 5.0, 6.5, 6.5
11	2.0	1.4687 5	2625	1.0	3.0	4.75, 15.75, 5.0, 24.875
12	2.0	1.5625	2625	0.5	3.0	5.25, 12.75, 4.5, 18.0
Av	2.0	1.5	3.0	0.5	5.25	6.0, 16.5, 6.5, 25.0, 15.5, 16.0, 14.75, 15.5, 18.5, 7.75, 7.75, 16.0, 6.75, 15.75, 7.0, 5.5, 15.0, 6.5, 6.5, 15.75, 24.875, 12.75, 18.0

Figure a7.24. ***Da Eh*** **Mb O2**

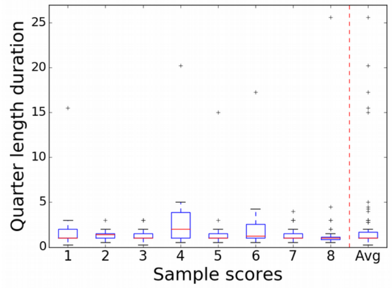

Table a7.24. ***Da Eh*** **Mb O2**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	2.0	0.25	3.0	15.5
2	1375	1.0	1.5	0.5	2.0	3.0
3	1.0	1.0	1.5	0.25	2.0	3.0, 3.0, 3.0
4	2.0	1.0	3875	0.5	5.0	20.25
5	1.0	1.0	1.5	0.5	2.0	3.0, 15.0
6	1.25	1.0	2.5625	0.5	4.25	17.25
7	1.0	1.0	1.5	0.5	2.0	3.0, 3.0, 3.0, 4.0, 3.0, 3.0, 3.0
8	1.0	875	1125	0.5	1.5	3.0, 4.5, 2.0, 25.625, 2.0, 3.0
Av	1.0	1.0	1.6875	0.25	2.0	3.0, 15.5, 3.0, 3.0, 3.0, 3.0, 2.75, 5.0, 20.25, 3.0, 15.0, 2.75, 2.75, 4.25, 17.25, 3.0, 3.0, 3.0, 4.0, 3.0, 3.0, 3.0, 3.0, 4.5, 25.625, 3.0

Figure a7.25. *Da Eh* Mb C

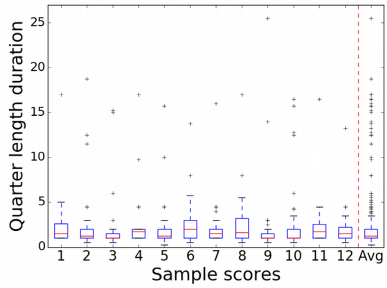

Table a7.25. *Da Eh* Mb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.5	1.0	2625	1.0	5.0	17.0
2	1.25	1.0	2.0	0.5	3.0	4.5, 12.5, 4.5, 18.75, 11.5
3	1.0	1.0	1.5	0.5	2.0	15.0, 3.0, 6.0, 15.25
4	1.75	1.0	2.0	1.0	2.0	4.5, 17.0, 4.5, 9.75
5	1.25	1.0	2.0	0.25	3.0	4.5, 15.75, 4.5, 10.0
6	2.0	1.0	3.0	0.5	5.75	13.75, 8.0
7	1.5	1.0	2.0	1.0	3.0	4.5, 16.0, 4.5, 4.0
8	1625	1.0	3.1875	0.5	5.5	17.0, 8.0
9	1.0	1.0	1.5	0.5	2.0	3.0, 3.0, 3.0, 3.0, 14.0, 3.0, 2.5, 25.5
10	1.0	1.0	2.0	0.5	3.5	4.25, 15.75, 4.25, 12.5, 12.75, 6.0, 16.5
11	1.75	1.0	2.53125	1.0	4.5	16.5
12	1.5	1.0	2.25	0.5	3.5	4.5, 13.25, 4.5
Av	1.25	1.0	2.0	0.25	3.5	4.5, 17.0, 4.5, 5.0, 4.5, 12.5, 4.5, 18.75, 11.5, 15.0, 6.0, 15.25, 4.5, 17.0, 4.5, 9.75, 4.5, 15.75, 4.5, 10.0, 4.0, 13.75, 3.875, 5.75, 8.0, 4.5, 16.0, 4.5, 4.0, 5.5, 4.75, 17.0, 5.0, 3.75, 5.25, 8.0, 14.0, 25.5, 4.25, 15.75, 4.25, 12.5, 12.75, 6.0, 16.5, 4.5, 16.5, 4.5, 4.5, 13.25, 4.5

Figure a7.26. *Da Xp* Mb

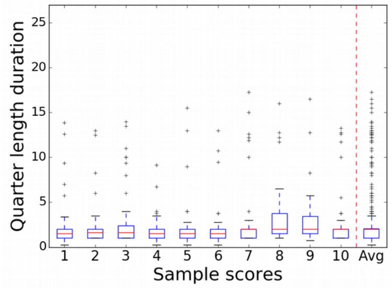

Table a7.26. *Da Xp* Mb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.5	1.0	2.0	0.25	3375	13.875, 12.625, 9.375, 5.75, 7.0
2	1625	1.0	2.0	1.0	3.5	8.25, 13.0, 12.5, 6.0
3	1625	1.0	2375	1.0	4.0	9.375, 11.0, 14.0, 13.5, 10.0, 6.0, 10.0, 8.0
4	1.5	1.0	2.0	0.25	3.5	6.75, 9.125, 3.75, 4.0
5	1.5	1.0	2.0	0.25	2.75	9.0, 4.0, 13.0, 15.5, 4.0
6	1.5	1.0	2.0	0.25	2.75	10.75, 3.75, 13.0, 3.75, 9.5
7	2.0	1.0	2.0	1.0	3.0	12.625, 15.0, 11.875, 12.25, 4.0, 17.25, 10.0
8	2.0	1.5	3.75	1.0	6.5	11.75, 16.0, 12.25, 12.75
9	2.0	1.5	3.4375	0.75	5.75	8.25, 16.5, 12.75
10	2.0	1.0	2.0	1.0	3.0	10.0, 12.75, 11.75, 13.25, 3.75, 12.625, 3.75, 5.5
Av	2.0	1.0	2.0625	0.25	3.5	13.875, 12.625, 9.375, 5.75, 7.0, 8.25, 13.0, 12.5, 6.0, 9.375, 11.0, 14.0, 4.0, 13.5, 10.0, 6.0, 10.0, 8.0, 6.75, 9.125, 3.75, 4.0, 9.0, 4.0, 13.0, 15.5, 4.0, 10.75, 3.75, 13.0, 3.75, 9.5, 12.625, 15.0, 11.875, 12.25, 4.0, 17.25, 10.0, 5.0, 11.75, 6.0, 16.0, 4.5, 12.25, 4.25, 12.75, 6.5, 5.75, 4.0, 8.25, 4.0, 16.5, 4.5, 12.75, 5.25, 5.75, 10.0, 12.75, 11.75, 13.25, 3.75, 12.625, 3.75, 5.5

Figure a7.27. *Da Xp* Mb O

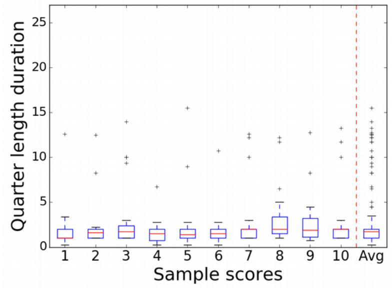

Table a7.27. *Da Xp* Mb O

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	1.0	2.0	0.25	3375	12625
2	1625	1.0	2.0	1.0	2.25	8.25, 12.5
3	1.75	1.0	2375	1.0	3.0	9.375, 14.0, 10.0, 10.0
4	1.5	0.75	2.0	0.25	2.75	6.75
5	1375	1.0	2.0	0.25	2.75	9.0, 15.5
6	1.5	1.0	2.0	0.25	2.75	10.75
7	2.0	1.0	2.0	1.0	3.0	12.625, 12.25, 10.0
8	2.0	1.5	3375	1.0	5.0	11.75, 12.25, 6.5
9	1875	1125	3.1875	0.75	4.5	8.25, 12.75
10	2.0	1.0	2.0	1.0	3.0	10.0, 11.75, 13.25
Av	1.75	1.0	2.0	0.25	3.5	12.625, 8.25, 12.5, 9.375, 14.0, 10.0, 10.0, 6.75, 9.0, 15.5, 10.75, 12.625, 12.25, 10.0, 5.0, 11.75, 4.5, 12.25, 6.5, 8.25, 4.5, 12.75, 10.0, 11.75, 13.25

Figure a7.28. *Da Xp* Mb C

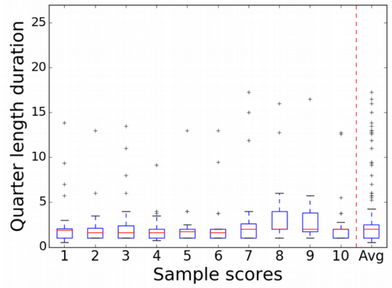

Table a7.28. *Da Xp* Mb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1875	1.0	2.0625	0.5	3.0	13.875, 9.375, 5.75, 7.0
2	1625	1.0	2125	1.0	3.5	13.0, 6.0
3	1625	1.0	2375	1.0	4.0	11.0, 13.5, 6.0, 8.0
4	1625	1.0	2.0	0.75	3.5	9.125, 3.75, 4.0
5	1.75	1.0	2.0	1.0	2.5	4.0, 13.0, 4.0
6	1625	1.0	2.0	1.0	2.0	3.75, 13.0, 3.75, 9.5
7	2.0	1.0	2625	1.0	4.0	15.0, 11.875, 17.25
8	2.0	2.0	4.0	1.0	6.0	16.0, 12.75
9	2.0	1.75	3.8125	1.0	5.75	16.5
10	2.0	1.0	2.0	1.0	2.75	12.75, 3.75, 12.625, 3.75, 5.5
Av	2.0	1.0	2.5	0.5	4.25	13.875, 9.375, 5.75, 7.0, 13.0, 6.0, 11.0, 13.5, 6.0, 8.0, 9.125, 13.0, 13.0, 9.5, 15.0, 11.875, 17.25, 6.0, 16.0, 12.75, 5.75, 16.5, 5.25, 5.75, 12.75, 12.625, 5.5

Figure a7.29. *Ls Xp* Kb

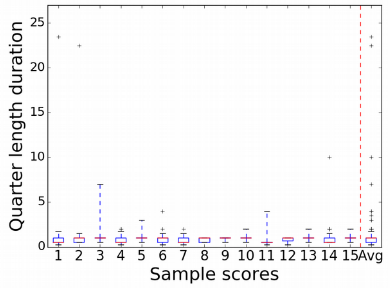

Table a7.29. *Ls Xp* Kb

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	0.5	0.5	1.0	0.25	1.75	23.5
2	1.0	0.5	1.0	0.5	1.5	22.5
3	1.0	1.0	1.0	0.5	7.0	
4	0.5	0.5	1.0	0.25	1.75	2.0, 2.0
5	1.0	1.0	1.0	0.5	3.0	
6	1.0	0.5	1.0	0.25	1.5	2.0, 4.0
7	0.5	0.5	1.0	0.25	1.5	2.0
8	1.0	0.5	1.0	0.5	1.0	
9	1.0	1.0	1.0	0.5	1.0	
10	1.0	1.0	1.0	0.5	2.0	
11	0.5	0.5	0.5	0.25	4.0	
12	1.0	0.6875	1.0	0.25	1.0	
13	1.0	1.0	1.0	0.5	2.0	
14	0.5	0.5	1.0	0.5	1.5	2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 10.0
15	1.0	1.0	1.0	0.5	2.0	
Av	1.0	0.5	1.0	0.25	1.75	23.5, 22.5, 2.0, 2.0, 7.0, 2.0, 2.0, 2.0, 2.0, 3.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 3.0, 2.0, 2.0, 4.0, 2.0, 2.0, 2.0, 2.0, 2.0, 3.5, 2.0, 4.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 10.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0

Figure a7.30. *Ls Xp* Kb O

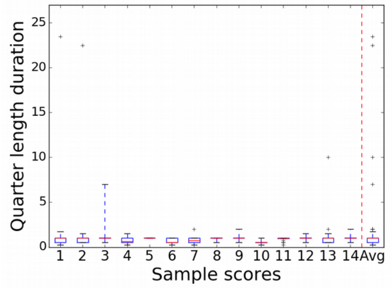

Table a7.30. *Ls Xp* Kb O

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	0.5	1.0	0.25	1.75	23.5
2	1.0	0.5	1.0	0.5	1.5	22.5
3	1.0	1.0	1.0	0.5	7.0	
4	625	0.5	1.0	0.25	1.5	
5	1.0	1.0	1.0	1.0	1.0	
6	0.5	0.5	1.0	0.25	1.0	
7	0.75	0.5	1.0	0.25	1.0	2.0
8	1.0	1.0	1.0	0.5	1.0	
9	1.0	1.0	1.0	0.5	2.0	
10	0.5	0.5	0.5	0.25	1.0	
11	1.0	0.9375	1.0	0.9375	1.0	0.5, 0.5, 0.5, 0.75, 0.25
12	1.0	1.0	1.0	0.5	1.5	
13	1.0	0.5	1.0	0.5	1.5	2.0, 10.0
14	1.0	1.0	1.0	0.5	2.0	
Av	1.0	0.5	1.0	0.25	1.75	23.5, 22.5, 2.0, 2.0, 7.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 10.0, 2.0, 2.0, 2.0

Figure a7.31. *Ls Xp* Kb C

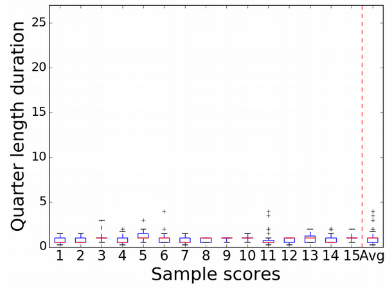

Table a7.31. *Ls Xp* Kb C

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	0.5	0.5	1.0	0.25	1.5	
2	0.5	0.5	1.0	0.5	1.5	
3	1.0	1.0	1.0	0.5	3.0	
4	0.5	0.5	1.0	0.25	1.75	2.0, 2.0
5	1.0	1.0	1.5	0.5	2.0	3.0
6	1.0	0.5	1.0	0.5	1.5	2.0, 4.0
7	0.5	0.5	1.0	0.25	1.5	
8	1.0	0.5	1.0	0.5	1.0	
9	1.0	1.0	1.0	0.5	1.0	
10	1.0	1.0	1.0	0.5	1.5	
11	0.5	0.5	0.75	0.25	1.0	3.5, 1.5, 2.0, 4.0, 2.0, 2.0
12	1.0	0.5	1.0	0.25	1.0	
13	1.0	0.5	1.25	0.5	2.0	
14	0.5	0.5	1.0	0.5	1.5	2.0, 2.0, 2.0, 2.0, 2.0
15	1.0	1.0	1.0	0.5	2.0	
Av	1.0	0.5	1.0	0.25	1.75	2.0, 2.0, 2.0, 2.0, 3.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 3.0, 2.0, 2.0, 4.0, 3.5, 2.0, 4.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0

Figure a7.32. ***Da Xp*** **Kb**

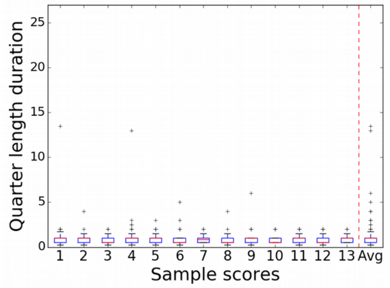

Table a7.32. ***Da Xp*** **Kb**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	0.5	1.0	0.25	1.75	2.0, 2.0, 2.0, 2.0, 2.0, 13.5, 2.0, 2.0, 2.0
2	1.0	0.5	1.0	0.25	1.5	2.0, 4.0
3	0.5	0.5	1.0	0.25	1.5	2.0, 2.0
4	1.0	0.5	1.0	0.25	1.5	2.0, 3.0, 2.0, 2.5, 2.0, 13.0, 2.0, 2.5
5	1.0	0.5	1.0	0.25	1.5	3.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0
6	0.5	0.5	1.0	0.25	1.0	2.0, 3.0, 2.0, 5.0
7	875	0.5	1.0	0.5	1.5	2.0, 2.0
8	0.5	0.5	1.0	0.25	1.5	2.0, 4.0
9	1.0	0.5	1.0	0.25	1.0	2.0, 6.0, 2.0, 2.0
10	0.5	0.5	1.0	0.5	1.0	2.0, 2.0, 2.0
11	1.0	0.5	1.0	0.25	1.5	2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0
12	0.5	0.5	1.0	0.25	1.5	2.0, 2.0, 2.0, 2.0, 2.0
13	1.0	0.5	1.0	0.5	1.5	2.0, 2.0
Av	1.0	0.5	1.0	0.25	1.75	2.0, 2.0, 2.0, 2.0, 2.0, 13.5, 2.0, 2.0, 2.0, 2.0, 4.0, 2.0, 2.0, 2.0, 3.0, 2.0, 2.5, 2.0, 13.0, 2.0, 2.5, 3.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 3.0, 2.0, 5.0, 2.0, 2.0, 2.0, 4.0, 2.0, 6.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0

Figure a7.33. ***Da Xp*** **Kb O**

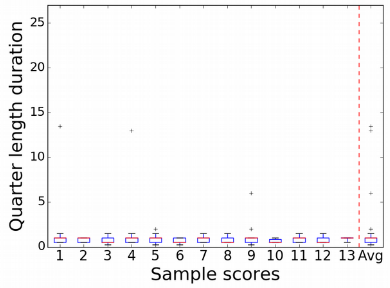

Table a7.33. ***Da Xp*** **Kb O**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	1.0	0.5	1.0	0.5	1.5	13.5
2	1.0	0.5	1.0	0.5	1.0	
3	0.5	0.5	1.0	0.25	1.5	
4	1.0	0.5	1.0	0.5	1.5	13.0
5	1.0	0.5	1.0	0.25	1.5	2.0
6	0.5	0.5	1.0	0.25	1.0	
7	1.0	0.5	1.0	0.5	1.5	
8	0.5	0.5	1.0	0.5	1.5	
9	1.0	0.5	1.0	0.25	1.0	2.0, 6.0
10	0.5	0.5	875	0.5	1.0	
11	1.0	0.5	1.0	0.5	1.5	
12	0.5	0.5	1.0	0.5	1.5	
13	1.0	1.0	1.0	0.5	1.0	
Av	1.0	0.5	1.0	0.25	1.5	13.5, 13.0, 2.0, 2.0, 6.0

Figure a7.34. ***Da Xp*** **Kb C**

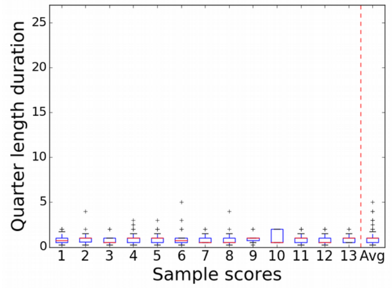

Table a7.34. ***Da Xp*** **Kb C**

In.	M.	Q1	Q3	L.f.	U.f.	Outliers
1	0.75	0.5	1.0	0.25	1.75	2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0
2	1.0	0.5625	1.0	0.25	1.5	2.0, 4.0
3	0.5	0.5	1.0	0.25	1.0	2.0, 2.0
4	1.0	0.5	1.0	0.25	1.5	2.0, 3.0, 2.0, 2.5, 2.0, 2.0, 2.5
5	1.0	0.5	1.0	0.25	1.5	3.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0
6	0.75	0.5	1.0	0.25	1.0	2.0, 3.0, 2.0, 5.0
7	0.5	0.5	1.0	0.5	1.5	2.0, 2.0
8	0.5	0.5	1.0	0.25	1.5	2.0, 4.0
9	1.0	0.75	1.0	0.5	1.0	0.25, 0.25, 0.25, 2.0, 2.0
10	0.5	0.5	2.0	0.5	2.0	
11	1.0	0.5	1.0	0.25	1.5	2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0
12	0.5	0.5	1.0	0.25	1.5	2.0, 2.0, 2.0, 2.0, 2.0
13	1.0	0.5	1.0	0.5	1.5	2.0, 2.0
Av	1.0	0.5	1.0	0.25	1.75	2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 4.0, 2.0, 2.0, 2.0, 3.0, 2.0, 2.5, 2.0, 2.0, 2.5, 3.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 3.0, 2.0, 5.0, 2.0, 2.0, 2.0, 4.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0, 2.0

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