Comparative Melodic Analysis of
A Cappella Flamenco Cantes

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Background in ethnomusicology and music analysis. A cappella singing styles (called cantes in the flamenco jargon) are among the most fundamental song styles within the flamenco repertoire. Until very recently, flamenco singers have been only using oral transmission to learn them. Because of this form of diffusion, melody has become one of the main musical facets to be listened to, remembered, elaborated and spread in flamenco singing styles. Moreover, melody has helped flamenco enthusiasts to remember and identify variants of a particular style or genre. A frequent discussion and unanswered question among flamenco scholars is how to quantify the similarity between two melodies, and how to use this similarity measure to differentiate different styles and variants among performers, and to study the roots and evolution of flamenco styles.

Background in computing, mathematics and statistics. State of the art techniques in melodic analysis of audio allow us to obtain different representation levels of a music recording (Gómez et alt. 2003). There are different representation levels for melody. Energy (intensity) and fundamental frequency (pitch) curves are the main low-level melodic features. In a higher structural level, note duration and pitch provide a symbolic representation, which can be the input to higher-level analyses. Finally, deviations of the analyzed recording with respect to the obtained score are related to expressivity. There have been some attempts to apply these techniques to the analysis of flamenco music (Donnier 1997, Gómez and Bonada 2008). There also a corpus of research on how to measure similarity between melodies using computational models, which are usually inspired in methods for string comparison (Crawford et alt. 1998, Mongeau and Sankoff 1990).

Aims. After some previous studies on rhythmic similarity of flamenco styles (Díaz-Bañez et alt. 2004), the aim of this work is to compare different approaches of melodic and tonal analysis of flamenco a capella singing styles. The ultimate goal is to perform a multidisciplinary analysis that will provide us with tools to compare different versions of the same style, and, as a consequence, to clarify the roots of styles and their evolution. We contrast historical knowledge, we carry out manual melodic and tonal analysis assisted with automatic melodic description tools. In order to achieve this goal, it is also necessary to gather a representative musical corpus, a significantly difficult task due to the variety of media (mostly vinyl and magnetic tapes) and poor quality of existing flamenco recordings.

Main contribution. One of the main contributions of this work is to gather a representative music collection for this study. The corpus was found on very diverse media (mostly vinyl and magnetic tapes), and comprises recording from the 40’s up to day. We have considered a music collection of songs without instrumentation or in some cases with some percussion, known in flamenco music as cantes a palo seco. This corpus is composed of two main styles,
Introduction

A cappella singing styles (called cantes or palos in the flamenco jargon) are among the main styles within the flamenco repertoire. Until very recently, flamenco singers have been only using oral transmission to learn them. In oral transmission, melody has become one of the main musical facets to be listened to, remembered, elaborated and spread in flamenco singing styles. Moreover, melody has helped flamenco enthusiasts to remember and identify variants of a particular style or genre. A frequent discussion and also unanswered question among flamenco scholars is how to quantify the similarity between two melodies, and how to use this similarity measure to differentiate different styles and variants among performers, and to study the roots and the evolution of flamenco styles.

After some previous studies on rhythmic similarity of flamenco styles (Díaz-Bañez et al. 2004), we intended to compare complementary approaches for the melodic and tonal analysis of flamenco a capella singing styles. The aim of this work is then to analyze flamenco singing melodies from different perspectives, and use such analyses to compare different versions of the same style. This would eventually lead to a clarification of the roots of styles and their evolution. We provided some historical information, manual melodic and tonal analysis and automatic melodic description tools for the analysis of a corpus of cantes. We carried out a clustering analysis based on similarity measures both for manual and automatic descriptions.

In order to achieve this goal, it is also necessary to gather a representative musical corpus, a significantly difficult task due to the variety of media (mostly vinyl and magnetic tapes) and poor quality of existing flamenco recordings.

A cappella flamenco Cantes

We consider a music collection made of songs without instrumentation or in some cases with some percussion, known in flamenco music as cantes a palo seco. This corpus is composed of tonás. Tonás are songs without any musical accompaniment that in a generic form encompass martinetes, deblas, saetas, tonás and carceleras. In this paper, we concentrate ourselves on two main styles, namely deblas and martinetes.

A toná is a song with a ‘copla’ of verses of either three or four or eight syllables, where the second and the forth verses may have assonant rhythm, which is usually finished with an imperfect tercet (off-rhyme tercet). Although its origin is uncertain, many people in the flamenco world believe that the toná is the mother of all flamenco styles (cante madre), and that from it all other styles are derived. Some researchers, honestly trying to build a corpus of research but not counting on a fully rigorous methodology, have dated its origin in the XVIII century in Jerez and Triana.
(Molina and Mairena 1963), but more recent studies propose a later appearance (Jaramillo 2002, among others). Many tonás have been given a particular name along history, especially due to the work of Molina and Mairena. Many of those names are merely names familiar to the singers, but they don’t reflect any musical feature. In spite of this fact, they speak about the toná del Cristo, toná de los pajaritos, toná liviana de Tía Sarvaoa, toná de la Junquera, toná de Jaunelo, etc.

The debla is a song that stems from the basis of the toná. Its melody requires a melismatic ornamentation, more abrupt than the rest of the songs of the tonás group.

The martinete is also considered a variety of the toná. It differs from the latter in lyrics and its melodic model, which always finishes in the major mode. It is usually a sad style and it is played without guitar accompaniment, as the tonás group. Nevertheless, martinetes are usually accompanied by the percussion of a mallet struck against an anvil.

Music collection

One of the main contributions of this work is to gather a representative music collection for this study. The corpus was found on very diverse media (mostly vinyl and magnetic tapes) and comprises recording from the 40’s up to day. In total, there are 135 monophonic voice pieces covering the most representative flamenco singers. Musicological, geographical and historical criteria were followed when selecting the pieces. For instance, the singer Tomás Pabón is known as the one who established the debla style, and some relevant contributors were Antonio Mairena and Naranjito de Triana. These last two artists are considered as the big masters from the 80’s, and they influenced all the rest of singers. Table 1 provides some details on this music collection.

The chosen pieces have been manually segmented into phrases, and we have selected the first phrase, as it provides the main melodic theme. This choice has been motivated by the rigidity of musical form that

Table 1. Set of analyzed pieces.

<table>
<thead>
<tr>
<th>Singer</th>
<th>Year</th>
<th>Location</th>
<th>School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antonio Mairena</td>
<td>1960</td>
<td>Mairena del Alcór</td>
<td>Pabón</td>
</tr>
<tr>
<td>Chano Lobato</td>
<td>2002</td>
<td>Cádiz</td>
<td>Pabón Mairena</td>
</tr>
<tr>
<td>Chocolate</td>
<td>1999</td>
<td>Jerez de la Frontera</td>
<td>Pabón Mairena</td>
</tr>
<tr>
<td>J. Almadén</td>
<td>1985</td>
<td>Ciudad Real</td>
<td>Pabón Mairena</td>
</tr>
<tr>
<td>Jesús Heredia</td>
<td>2002</td>
<td>Écija</td>
<td>Pabón Mairena</td>
</tr>
<tr>
<td>M. Simón</td>
<td>1985</td>
<td>Jerez de la Frontera</td>
<td>Pabón</td>
</tr>
<tr>
<td>M. Vargas</td>
<td>1972</td>
<td>Cazalla de la Sierra</td>
<td>Mairena</td>
</tr>
<tr>
<td>Naranjito</td>
<td>2002</td>
<td>Triana (Sevilla)</td>
<td>Pabón Mairena</td>
</tr>
<tr>
<td>Pepe de Lucía</td>
<td>1963</td>
<td>Algeciras</td>
<td>Pabón</td>
</tr>
<tr>
<td>Talegón</td>
<td>2002</td>
<td>Córdoba</td>
<td>Pabón Mairena</td>
</tr>
<tr>
<td>Tomás Pabón</td>
<td>1950</td>
<td>Triana (Sevilla)</td>
<td>El Baboso</td>
</tr>
<tr>
<td>Turronero</td>
<td>1989</td>
<td>Utrera</td>
<td>Pabón Mairena</td>
</tr>
</tbody>
</table>

Table 2. Keys of the analyzed Deblas.

<table>
<thead>
<tr>
<th>Singer</th>
<th>Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antonio Mairena</td>
<td>C Major</td>
</tr>
<tr>
<td>Chano Lobato</td>
<td>Bb Major</td>
</tr>
<tr>
<td>Chocolate</td>
<td>G Major</td>
</tr>
<tr>
<td>J. Almadén</td>
<td>B Major</td>
</tr>
<tr>
<td>J. Heredia</td>
<td>Bb Major</td>
</tr>
<tr>
<td>M. Simón</td>
<td>C Major</td>
</tr>
<tr>
<td>M. Vargas</td>
<td>A Major</td>
</tr>
<tr>
<td>Naranjito</td>
<td>C Major</td>
</tr>
<tr>
<td>Pepe de Lucía</td>
<td>C# Major</td>
</tr>
<tr>
<td>Talegón</td>
<td>C# Major</td>
</tr>
<tr>
<td>Tomás Pabón</td>
<td>Bb Major</td>
</tr>
<tr>
<td>Turronero</td>
<td>B Major</td>
</tr>
</tbody>
</table>

martinete and debla exhibit. From these 135 excerpts, we have started by selecting 12 singers with the most representative deblas and martinetes.

Tonal analysis


A tonal analysis of the selected 12 deblas in terms of global key and modulations is provided in this section. The analyzed deblas provides a modal context, according to the following tonal structure: Tonic (I) - Subdominant (IV) - Tonic (I). We observe a wide range of keys at the analyzed pieces, as shown in Table 2.

According to its key, we identify 6 different groups: pieces in G Major (Chocolate), A Major (Vargas), Bb Major (Pabón, Lobato and Heredia), B Major (Almadén and Turronero), C Major (Mairena, Simón and Naranjito) and C# Major (Pepe de Lucía and Talegón).

We also observe the presence of microtonality in the modulations; most of the times this is due to tuning problems. In fact, the flamenco singer is not trained to perform accurate modulations whatsoever, at least in traditional flamenco singing.

The key is mostly related to the particular tessitura of the singer, but we might wonder if the chosen key could be also related to a similarity between singing styles. For instance, did Lobato and Heredia follow Pabón’s version (in Bb Major)? Or did Simón and Naranjito follow Mairena’s version (in C Major)?

**Manual melodic transcription and clustering**

A manual melodic analysis of our initial corpus was made by a flamenco expert (with formal musical training also).

For this manual analysis we have first normalized the melodic contour with respect to the tonic, and notes have been approximated to the closest note in the equal-tempered scale. Then, ornamentations or melisma have been removed according to some previous knowledge of the particular style under analysis.

There is no straight rhythmic representation, as manual annotation has been made following perception of rhythmic pulses, and not according to note durations.

Figures 1-a and 1-b show graphical representations of the main melodic contour of a debla performed by Antonio Mairena and Tomás Pabón respectively. The reader may observe that there are short-time differences, although the overall melodic contour is similar.
Figures 2-a and b show graphical representations of the main melodic contour of a *martinetes* sung by Antonio Mairena and Tomás Pabón, respectively. We also found some short-time differences, although the overall melodic contour is kept.

With these manual patterns we have performed a similarity study based on multidimensional scaling, by using the Euclidean distance between the vector representations of the sequential values of melodies. A two-dimensional projection of the d-dimensional data is presented in Figure 3. We observe that *martinetes* (M) and *deblas* (D) are located in different regions of the 2-D plot. Note that *martinetes* from Mairena and Pabón (Tomás) are close to each other, whereas their *deblas* are very far away from each other.

**Computational analysis**

A computational analysis is made in order to automate the melodic transcription and use alternative similarity distances proposed in the literature.

State of the art techniques in automatic melodic analysis of audio allow us to obtain different representation levels of a music recording (Gómez et al. 2003). There are different representation levels for melody. Energy (intensity) and fundamental frequency (pitch) curves are the main low-level melodic features. In a higher structural level, note duration and pitch provide a symbolic representation, which can be the input to higher-level analyses. Finally, deviations of the analyzed recording with respect to the obtained score are related to expressivity. There have been some attempts to apply these techniques to the analysis of flamenco music (Donnier 1997, Gómez and Bonada 2008).
Automatic melodic transcription

We have tested two methods for automatic melodic analysis (Gómez and Bonada 2008, Leman et al. 2003), which allow us to obtain a MIDI-like representation of singing melodies (onsets, offsets and frequency of every pitch event). It’s important to note that each singer has its own reference tone in mind and he/she sings each note relatively to the scale constructed on that tone (Haus and Pollastri, 2001). It is then necessary to estimate this tuning frequency by dividing the semitone into ten overlapping bins, each one being 0.2 semitones wide with an overlapping region of 0.1 semitones. The mean of the deviations that belong to the maximum bin is the constant average distance in semitones from the user’s reference tone. Thus, the scale can be shifted by this estimated amount.

Figures 4-a and 4-b provide a graphical representations of the extracted melodic contour of a *debla* performed by Antonio Mairena and Tomás Pabón respectively. We observed some differences with respect to manual annotations. Although there are some errors in the automatic transcription due to the lack of tuning, most of the differences are due to simplifications and assumptions made when manually labeling the melodies (i.e. melisma are not considered, note durations are neglected and only the main melodic anchor points are notated).

Once we had every piece converted into MIDI notes, we needed to normalize it with respect to the key, so that the melodic representation is invariant to transposition. In order to obtain this, we compute the intervals between consecutive pitches, instead of working with the absolute pitch values.
Besides, we wanted the representation of the pieces not to be affected by tempo. We then normalized note durations with respect to the duration of the previous note.

**Measures for similarity computation**

There is a vast corpus of research on how to measure similarity between melodies using computational models, usually inspired in methods for string comparison (Crawford et al. 1998, Mongeau and Sankoff 1990).

We implemented several melodic similarity measures. As a preliminary study, we have computed some of them so far to find out which measure would be the most appropriated for our study. For the time being, we have dealt with two different measures.

The first one is the **correlation coefficient between note histograms**. We measured how interval distributions correlate without considering its ordering. Correlation indicates the strength and direction of a linear relationship between two random variables. We obtained this coefficient for each pair of pieces, resulting in a similarity matrix.

The second measure considered was the distance between the note sequences: the **edit distance** (Mongeau and Sankoff 1990). It is a metric that counts the difference between two sequences under certain operations. The edit distance between two strings is given by the minimum number of operations needed to transform one string into the other, where an operation is an insertion, deletion, or substitution of a single note. Both pitch and note duration information were considered in

![Diagram of a SplitTree for 12 Deblas and 12 Martinetes.](image-url)

Figure 5. A SplitTree for 12 Deblas and 12 Martinetes.
the algorithm, as they increases the
discrimination (López and Rocamora 2005).

**Phylogenetic trees**

In addition to similarity analysis, a
phylogenetic analysis is made in order to
study relationships among the transcribed
performances.

Several techniques exist for generating
phylogenetic trees from distance matrices.
Once we computed the different similarity
matrixes, we generated a phylogenetic tree
using the tool SplitsTree (Huson 1998).
SplitsTree computes a tree with the property
that the distance in the drawing between any
two nodes reflects as closely as possible the
true distance between the corresponding two
pieces in the distance matrix. In Figure 5 we
can see a SplitsTree generated with the
similarity matrix between note histograms. As
expected, due to the different melodic
contour of every style, two clusters appeared:
a first cluster with the *deblas*, and a second
clearly distinct cluster including the
*martinetes*.

**Conclusions and future work**

Melody is one of the most important aspects
to be considered in the analysis of a cappella
flamenco singing styles. Automatic melodic
description tools can be effectively used to the
analysis of flamenco singing. These automatic
tools allow obtaining quantitative and
qualitative measures that can complement
historical and musical data (and other types)
on the roots and evolution of oral
transmission of flamenco styles.

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