THE SEILS DATASET: SYMBOLICALLY ENCODED SCORES IN MODERN-EARLY NOTATION FOR COMPUTATIONAL MUSICOLOGY

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ABSTRACT

The automatic analysis of notated Renaissance music is restricted by a shortfall in codified repertoire. Thousands of scores have been digitised by music libraries across the world, but the absence of symbolically codified information makes these inaccessible for computational evaluation. Optical Music Recognition (OMR) made great progress in addressing this issue, however, early notation is still an on-going challenge for OMR. To this end, we present the Symbolically Encoded *Il Lauro Secco* (SEILS) dataset, a new dataset of codified scores for use within computational musicology. We focus on a collection of *Italian madrigals* from the 16^{th} century, a polyphonic secular a cappella composition characterised by strong musical-linguistic synergies. Thirty madrigals for five unaccompanied voices are presented in modern and early notation, considering a variety of digital formats: Lilypond, Music XML, MIDI, and Finale (a total of 150 symbolically codified scores). Given the musical and poetic value of the chosen repertoire, we aim to promote synergies between computational musicology and linguistics.

1. INTRODUCTION

Since scores are the only remaining source of Renaissance music, they are essential for replication and analysis of this repertoire. Through the analysis of an early score it is possible to identify musical similarities between composers [24], as well as correlations between poetry and music [32]. Due to this, libraries and museums spend great effort in the digitisation of early documents. This practice allows for easier dissemination of the repertoire and preserves it from the inevitable degradation.

Nevertheless, since this mass of scores have been scanned manually, no symbolically codifiable information is available, which makes them meaningless for computational procedures (e. g., automatic analysis). Furthermore, in digital libraries of symbolically encoded scores, transcriptions in modern notation of early musical repertoire are restricted, and early notation is almost completely ignored.

To resolve this issue, Optical Music Recognition (OMR) has been applied to early music [6, 10, 26, 28]. However, the degraded conditions of early documents (some times unreadable), and the linguistic inconsistencies between the different voices (common in vocal polyphonic music), make expert intervention essential, in some cases. Therefore, despite obtaining promising results, early notated music is still an open challenge for OMR [3]. With this in mind, we present the Symbolically Encoded *Il Lauro Secco* (SEILS) dataset [1]. The SEILS dataset is a corpus of scores encoded in a variety of digital formats (Lilypond [22] [2], Music XML, MIDI and Finale [3]) and musical notation styles (*white mensural* notation [2] and modern Western notation) deliberately selected to maximise computational possibilities. Furthermore, considering the strong synergies between poetry and music typical of the chosen repertoire, the presented dataset aims to promote, from a musicological, linguistic and historic perspective, further understanding of the artistic manifestations of the 'Humanism Renaissance'.

In particular, the SEILS dataset is suitable for musical-linguistic pattern recognition, given the prominent relationship between music and lyrics that characterise the *Il Lauro Secco* anthology. Furthermore, since each *madrigal* (piece) of the considered repertoire is composed by a different composer, the SEILS dataset will also allow for automatic identification of composers' similarities. In addition, by presenting a codified version in *white mensural* notation (ground truth), OMR technology will be able to evaluate its performance. In section 2 we will evaluate previous studies related to the presented issue. In section 3 the considered repertoire will be described. An overview of the criteria for symbolic codification and an evaluation of the considered digital formats will be given in sections 4 and 5. Finally, the conclusions in Section 6.

[1] https://github.com/SEILSdataset/SEILSdataset
[2] http://lilypond.org/
[3] http://www.finalemusic.com

2. RELATED WORK

Even though scores are a great source of knowledge, codified symbolic information is missing for many. Some attempts have been made to improve this, mainly through OMR systems [4, 23, 31]. OMR has also been applied for processing early music by several initiatives: SIMSSA [10] [4], ARUSPIX [26] [5], and GAMERA [6]. OMR, when used with early notation, examines tablature and mensural notation [25], as well as primitive notation [15] and lyric recognition [3]. Nevertheless, the degraded conditions of the original source and the inconsistencies in the lyrics for vocal polyphonic music make human intervention crucial in many cases.

The score collections available online consider an increasing variety of digital formats. The most commonly found formats are Music XML and MIDI; however, other digital formats are becoming more popular: e. g., the **kern format [17] (available in the ELVIS database [1] [6], music21 [5] [7], and the kernscores database [29] [8]); Lilypond files [22] [9] (available in the Petrucci Music Library – IMSLP [10] and the MUTOPIA project database [11]); or files encoded through the professional music notation software Finale [12] (available in IMSLP). Nevertheless, despite rare exceptions like *Tasso in Music Project* [27] [13], *The Marenzio Online Digital Edition* – MODE [14], *Josquin Research Project* [15], or the *Liber Usualis* [16] encoded in MEI [16], early music in such a variety of formats is still limited.

3. THE SEILS DATASET REPERTOIRE

The musical repertoire considered for the presented dataset is the *Italian madrigal* of the 16^{th} century, a secular polyphonic vocal composition in the Italian language, commonly for five to six unaccompanied voices. This kind of madrigal is characterised by meticulous musicalisation of poetic texts, a strategy known as *madrigalism* [14]. Towards the end of the 16^{th} century, this composition technique was refined and flourished into a rich and virtuous music [7], characterised by its use of lyrics from great poets of the time [21]. The synergy between poetry and music, prominent within these madrigals, makes them an icon of the 'Humanism Renaissance' [13]. Given the relevance of this intellectual movement to Western Europe, the considered repertoire has great importance not only to Italian heritage [9], but also to musicological, linguistic, and historical research.

[4] https://simssa.ca/
[5] http://www.aruspix.net/
[6] https://database.elvisproject.ca/
[7] http://web.mit.edu/music21/
[8] http://kern.ccarh.org/
[9] http://lilypond.org/
[10] http://imslp.org/
[11] http://www.mutopiaproject.org/
[12] http://www.finalemusic.com
[13] http://www.tassomusic.org/
[14] https://d2q4nobwyhnvov.cloudfront.net/86940d50-206f-4db3-9b88-754dddb3486f/92KX7friyUw0WA/index.html
[15] http://josquin.stanford.edu/
[16] http://music-encoding.org/

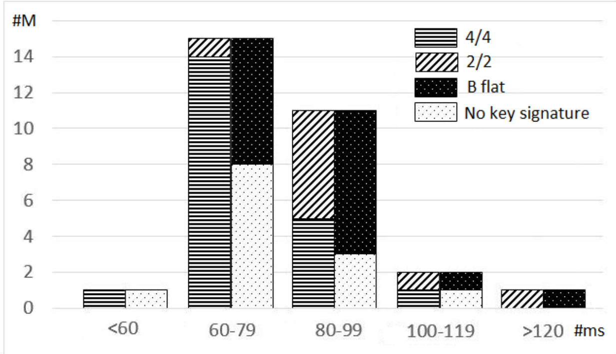

Figure 1: Distribution of the 30 madrigals utilised, considering: number of madrigals (#M), measure length (#ms), time signature (4 / 4 and 2 / 2), and key signature (B flat and no key signature).

3.1 *Il Lauro Secco* Anthology

The presented dataset is a codified version of the madrigal anthology *Il lauro Secco* (The dry laurel) [18], a collection of 31 Italian madrigals written by a variety of highly reputable composers from the end of the 16^{th} century. For consistency, only 30 of these madrigals (for five a cappella voices, each written by a different composer), are available in the presented dataset. The 31st (and last) madrigal in the anthology has been excluded from the dataset, as it is starkly different from the others (for ten voices, and composed by one of the previously considered composers).

The presented anthology has been chosen for its high level of musical–linguistic consistency, i. e., composed with both music and lyrics expressively written for the anthology [20]. Such content is unique, as a standard for anthologies was to be created from pre-existing compositions, without musical or linguistic relationships. This homogeneity across the anthology allows for an inter-score musical-linguistic analysis, which will enable for a deeper understanding of composer similarities via automatic recognition methods.

Both the music and lyrics of *Il lauro Secco* have been written by some of the most important Italian figures of this period. Several composers belong to the *Compagnia Romana*, also known as *Eccellenti Musici di Roma* (Excellent Musicians of Rome) [24], a congregation of composers famous for their proficiency. Furthermore, even though the authorship of the lyrics is not declared in the anthology, many have attributed this to the great Italian poet, Torquato Tasso [8, 12, 30].

3.2 The SEILS Dataset Statistic Evaluation

Considering the modern notated transcriptions, the presented madrigals display a mean average length of 79.5 measures (with a standard deviation of 15.7). Of the 30 madrigals, 21 are in 4 / 4 time signature and 9 in 2 / 2; 13 have a B flat in the key signature and 17 do not have alterations declared. In Figure 1, an overview of the distribution of madrigals is given, considering number of measures as well as key and time signature.

Although there is a high level of musical-linguistic consistency, the considered anthology is prominently characterised by its varying rhythms that differ between madri-

	16th	*8th*	*4th.*	*2nd*	*breve*	*acc*
Belli	0	42	17	251	4	**63**
Eremita	0	127	61	**167**	7	34
Fiorino	**8**	62	19	295	0	25
Luzzaschi	0	65	15	**348**	5	11
Macque	0	**265**	48	170	1	34
Massaino	0	173	40	248	**12**	36
Perue	2	**35**	11	168	0	21
Spontone	2	73	28	269	2	**7**
Strigio	0	252	**85**	271	2	29
Zoilo	0	27	**2**	187	2	25
30M	60	3222	958	7399	117	817
mean (30M)	2	107.4	31.9	246.6	3.0	27.3
sd (30M)	2.4	66.8	19.7	52.8	3.6	14.4

Table 1: Occurrence of sixteenth- (16th), eighth- (8th), quarter dotted- (4th .), half- (2nd), and double whole- (breve) notes, as well as accidentals (acc) within the madrigals (identified by composer name). Max. and min. values, for occurrences across the dataset, are highlighted in bold. Mean and standard deviation (sd), are given considering all madrigals together (30M).

gals. Some madrigals are virtuosic, i. e., showing more 'syncopation' (rhythms off-beat generally represented in music by dotted-notes), and fast notes (sixteenth- and eighth-notes). Others are more 'sustained', i. e., showing more long notes (double whole-notes), or are 'harmonically' more unstable, i. e., showing more 'accidentals' (notes of a pitch that do not belong to the scale declared in the key signature). To illustrate the distributions of notes and accidentals, in Table 1 statistics for specific madrigals are given which include extreme occurrences (maximum and minimum values), as well as across all madrigals in the data set.

The considered anthology presents a balanced distribution of voice types: 15 of the 30 madrigals are composed for 'medium' vocal range (range from *baritone* to *mezzo-soprano*); the other 15 are composed for 'extreme' vocal range, i. e., 7 for 'high' range (*tenor* to *soprano*), and 8 for 'low' range (*bass* to *contralto*). Two of the 15 madrigals for 'medium voices' (those composed by Marenzio and Luzzaschi), display the maximum 'extension' (i. e., vocal range considering all five voices) of the anthology (between G2 – 97.9 Hz, and G5 – 783.9 Hz). The highest note performed is A5 – 880 Hz, being present only in Massaino's madrigal; whereas the lowest is E2 – 82.4 Hz, performed in the madrigal composed by Spontone.

4. SYMBOLIC SCORE CODIFICATION

4.1 Original Notation and Modern Transcription

The original notation in which the madrigals of *Il Lauro Secco* have been written in the 16^{th} century is the *white mensural* notation (cf. Figure 2) [2]. Two editions of this musical source in early notation are available [18], both digitised and freely available online. The first was printed in 1582 by Vittorio Baldini in Ferrara (Italy) and is available from the Music Library of Bologna [17] as well as from

[17] http://www.bibliotecamusica.it/cmbm/scripts/gaspari/scheda.asp?id=7156

Figure 2: First staff of Marenzio's madrigal of the first edition (1582) of *Il Lauro Secco* written in *white mensural* notation.

IMSLP [18]. The second, printed in 1596 by Angelo Gardano in Venice, is available from the Gallica Digital Library [19]. Both editions have been used in the codification of the symbolic scores, collecting missing information of the first from the second when necessary and vice versa.

Based on the original source, two transcriptions have been made: one in *white mensural* notation (early notation), and another in modern notation. Both types have been chosen for their inherent advantages, and are available in Lilypond format. Since proficiency in early notation requires a level of musicological expertise, rare even in subjects from the musical field, symbolically codified transcriptions in modern notation are essential, offering a more understandable version of the repertoire.

On the other hand, the codified transcriptions in early notation, having the same notation as in the original source, provide the ground truth necessary to evaluate the performance of OMR systems (cf. Figure 3). Furthermore, since early notation do not split the notated music in 'measures' (segments within the 'staff' delimited by bar lines), 'ties' (the symbol used to link notes with the same pitch across different measures), are not required. This means that the symbolic representation of rhythm is always exactly the same, and never made of different note symbols, something typical of modern notation (cf. Figure 4). Since in modern notation, the codification of a given rhythm within a measure is different from the one across two measures, scores encoded in early notation would be more suitable for musical pattern recognition.

4.2 Musical Criteria

Even though in the original scores the individual vocal lines are written on different sheets, when engraving visually the proposed codified versions in Lilypond format (for both modern and early notation), the five voices are placed vertically superimposed (cf. Figure 3); the same holds for the modern transcription encoded in Finale. Computationally this does not make any difference, but we chose this arrangement because, from the musicological and linguistic point of view, vertical alignment is essential for effective analysis.

As early notation does not present 'bar lines', these are not considered in the scores encoded in Lilypond format, neither for early nor for modern notation (to allow for a visual comparison between both). Nevertheless, since bar lines are typical (if not mandatory) for modern notation, dashed bar lines have been considered incorporated in the

[18] http://imslp.org/wiki/Il_Lauro_secco_(Various)
[19] http://gallica.bnf.fr/ark:/12148/btv1b8449068j

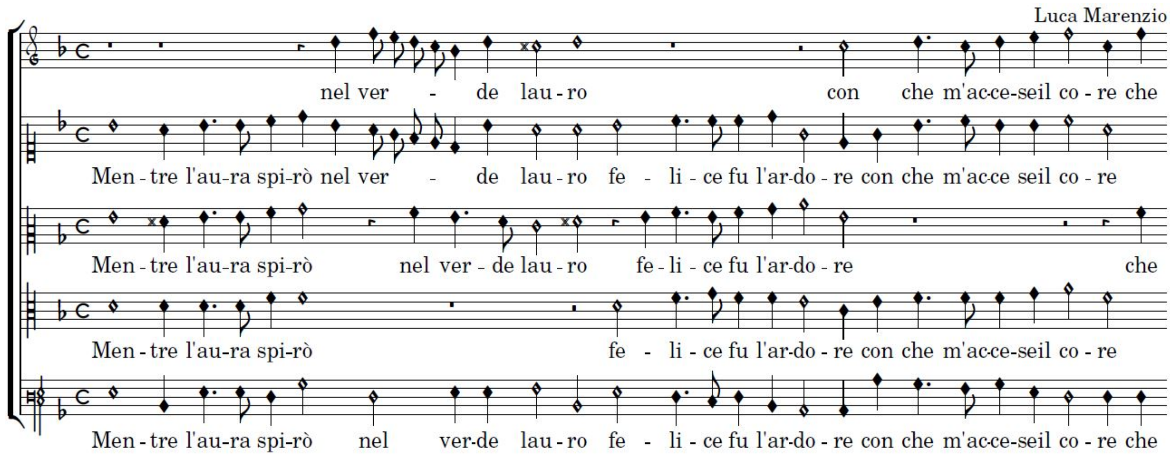

Figure 3: Visual representation of the transcription in *white mensural* notation (early notation) of the first staff of Marenzio's madrigal encoded by Lilypond. Unlike the original source, the voices are visually superimposed.

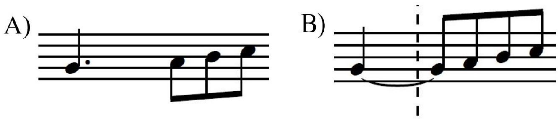

Figure 4: Two symbolic representations of the same rhythm. A) within a measure (encoded in Lilypond by: g4. a8 b8 c8); B) across two measures (in Lilypond: g4 ∼ g8 a8 b8 c8).

modern notated scores encoded in Finale (as commonly applied for modern transcription of early repertoire).

In early notation, accidentals are not always clearly indicated. Due to this, in critical editions of early repertoire, a 'cautionary accidental' (accidental placed above the note), is usually given by the musicologist as a suggestion. However, even these suggestions are given based on musical rules, such as consonances and dissonances created by the vertical collisions between notes, many times there is no full agreement between musicologists. Indeed, 'cautionary accidentals' can be displayed even by the musicologists themselves in two different ways, i. e., enclosed in parentheses above the note (when suggested), or without parentheses (when strongly suggested).

Based on these considerations, in the scores encoded in Lilypond, Music XML, and MIDI format, only the accidentals shown in the original source will be taken into account; whereas in the scores encoded in Finale, cautionary accidentals (both enclosed within parentheses or not), have been included to assist musicological analysis and potential musical performance. Furthermore, the symbols given for the accidentals in the original source (sharps and flats), had been respected in the early notated transcriptions, whereas these have been changed into naturals, when necessary, in the modern notated transcriptions (according to modern notation rules).

In mensural notation, 'ligatures' are groups of notes encoded with a unique graphical symbols. The interpretation of ligatures is made according to specific rules, and the notes involved are at least semibreve, i. e., only 'long' notes are involved [2]. Ligatures are relatively rare in the presented repertoire, being only 18 in the 30 madrigals (consider that each madrigal has at least 550 note symbols). Moreover, ligatures are never involved in musical-linguistic patterns (since these are made up of shorter notes). For these reasons, we encoded ligatures as single notes instead of a unique graphical symbol. In the scores encoded in Finale, a square bracket has been used to indicate the notes originally involved in the ligature (as is usual in modern transcriptions of early repertoire).

Finally, long rests (e. g., maxima rest), have been codified differently lasting a maximum of the whole rest, i. e., whole measure. This is the normal practice in modern notation, but not in early notation, where values are not determined by measure length. However, in order to save encoding time, and given that neither long rests nor graphical appearance have a role for musical analysis purposes, this practice has been adopted for the encoding in both early and modern notation.

4.3 Linguistic Criteria

In the original source, lyrics are placed in two locations of the score: under the notated music (for each one of the five voices), and in a poem format at the left of each music-sheet. Differences between these lyrics are typical of this repertoire, e. g., random use of abbreviations, missing accents and punctuation, or different spelling of the same word (cf. Figure 5). These inconsistencies create a challenge for OMR, and make automatic analysis an extensive task (since no musical-linguistic patterns can be identified in a non-unified text). For this reason, to encode this repertoire according to a uniform version, considering musical-linguistic criteria is essential.

Differences between the first edition of the source (1582) and the second (1596) have been found as well, the reprinted version being characterised by the use of more 'textual contractions' (e. g., *verd'io* instead of *verde io*, or *sott'ai* instead of *sotto ai*). Evaluating this, in the presented dataset, the standardisation of the lyrics has been made according to the first edition of the anthology (1582), and the lyrics have been presented only under the musical notation. The following linguistic criteria have been considered [11]:

I. Linguistic aspects faithful to the Italian language of the 16th century:

A) The etymological 'h' that does not produce pronunciation changes (e. g., in 'hor'), has been conserved;

Figure 5: First staff of the Marenzio's madrigal for *Alto* (shown above) and *Basso* (shown below) voices. The inconsistencies of the lyrics between both voices are highlighted: *uerde* vs *verde*, *lauro* vs *Lauro*, and *fù* vs *fu*, between *Alto* and *Basso*, respectively.

B) The graphical symbol 'ti', that must be pronounced 'zi' according the modern Italian phonetic rule, has been conserved;

C) The *tironian* symbol '&' has been transcribed as 'et', according the Italian orthographic rule of the 16^{th} century;

D) In the cases where contracted and not contracted textual versions have been presented (e. g., *altrov'adopra* and *altrove adopra*), the not contracted version has been considered. Nevertheless, in the musical performance, the synalepha, i. e., to merge two syllables into one, has to be made.

II. Linguistic aspects faithful to the modern Italian language:

A) The diacritic mark has been normalised according to the modern rule (e. g., *'più'* instead of *'piu'*, and 'a' instead of 'à', cf. Figure 5);

B) The arbitrary use of 'u' and 'v' in the different voices has been normalised according to the modern rule (e. g., *verde* instead of *uerde*, cf. Figure 5);

C) The abbreviation of 'n' and 'm' as superscripts on vowels with ∼ has been normalised by the complete spelling (e. g., *hanno* instead of *hãno*);

D) The abbreviation of *'per'* through *'p̱'* has been normalised by the complete spelling (e. g., *perché* instead of *p̱che*);

E) The abbreviation *'ij'*, referring to the repetition of sentences or words, has been substituted by the complete form;

F) Separated words have been normalised according to the modern rule (e. g., *invano* instead of *in vano*, or *poiché* instead of *poi che*).

III. Linguistic aspects considered in order to allow automatic musical-linguistic pattern recognition:

A) The punctuation has been standardised in all the voices, considering the prosody of the text but at the same time encouraging its simplification in order to allow musical-linguistic pattern recognition (where normalised punctuation between the different voices is essential);

B) The use of capital- and minor-letters has been standardised in all the voices, considering capital–case at the beginning of each verse and personification (cf. Figure 5). In order to prioritise the coherence between the different voices, vertical collisions between musical-linguistic patterns have been considered. According to this, the starting word of the repetitions of verses has been also capitalised.

Finally, melismatic prosody between syllables of the same word (i. e., a single syllable of text is sung through several different notes), has been graphically identified by dashes for both early and modern notation, as in the original source. However, when the melisma is placed at the end of the word, no graphical indication has been given in the early notated scores, following the original source. On the contrary, for the transcription in modern notation (both encoded in Lilypond and Finale), the length of the melisma has been indicated by an underscore.

5. DIGITAL FORMATS EVALUATION

As mentioned, the 30 madrigals have been encoded in four digital formats: Lilypond, Music XML, MIDI, and Finale. Early and modern notation are available in Lilypond format (a total of 60 files), whereas the Finale format has been considered only to encode modern notated transcriptions (30 files), and from these, Music XML and MIDI files have been automatically created (30 for each).

Each format has differing pros and cons for computational musicology. For example, Music XML files show clear links between linguistic information and associated notes, which helps for the automatic identification of musical-linguistic connections. In the following, we show the Music XML code (Code 1), used to indicate the first note of the *Alto* voice in the transcription in modern notation of Marenzio's madrigal (the original early notated version of this is shown in the top staff of Figure 5).

Code 1: Music XML syntax

```
<note default-x="121">
  <pitch>
    <step>B</step>
    <alter>-1</alter>
    <octave>4</octave>
  </pitch>
  <duration>8</duration>
  <voice>1</voice>
```

```
9     <type>whole</type>
10     <lyric default-y="-80" number="1">
11       <syllabic>begin</syllabic>
12         <text>Men</text>
13     </lyric>
14   </note>
```

As we can see, each line of the code indicates a specific musical parameter (e. g., line 3 the pitch, line 9 the note, line 12 the syllable). Nevertheless, this disposition breaks up the continuity of the musical patterns, complicating the performance of automatic analysis.

In contrast, Lilypond files have a clearer distribution of the musical patterns over the code lines, according to each measure (indicated in the following Lilypond code, i. e., Code 2, by " | % "). This facilitates computational operations such as automatic identification of rhythmic-melodic patterns, especially in scores encoded in early notation (where a given rhythm never indicates different shapes). In the following, we show the Lilypond code (Code 2) used to indicate the first staff of the *Alto* voice in the transcription in modern notation of Marenzio's madrigal (the original version of this, is shown in the top staff of Figure 5).

Code 2: Lilypond syntax

```
\key f \major
\time 4/4
\autoBeamOff
 bes'1        | % 1
 a4 bes4. bes8 c4      | % 2
 d bes a8 g f e       | % 3
 d4 bes' a2       | % 4
 a bes       | % 5
 c4. c8 c4 d       | % 6
```

As we can see, in each line of Lilypond, a whole measure is encoded, giving a more compact and meaningful distribution of the music. Indeed, whereas in 14 lines of Music XML, only one note is encoded, in the 9 lines of Lilypond, 20 notes are encoded, i. e., the whole first staff. In these 9 lines, not only the note length is encoded but also the pitch, accidentals, and octave (e. g., "4" means quarter-note, "bes" means B flat, and " ' " indicates the 4^{th} octave), as well as additional graphical information (e. g., " \autoBeamOff " indicates not to link the eighth-notes by a beam, typical of modern notation).

However, in Lilypond format, the lyrics are described in a different section of the code respectively to the notes, and without measure wise alignment. The link between notes and syllables is given by a single space to indicate that the following syllable is aligned to the following note and does not belong to the same word. To link syllables of the same word that are aligned to different notes the command " −− " is used (rests are not considered). In a melismatic passage, to indicate that an extra note must be skipped, the command " \skip4 " is used. Following this, the first verse sung by the *Alto* voice in the Marenzio's madrigal is encoded in Lilypond as follows (the original early notated version of this, is shown in the top staff of Figure 5):

Men −− tre l'au −− ra spi −− rò nel ver −− \skip4 \skip4 \skip4 \skip4 de lau −− ro

MIDI is probably the most common digital format for music dissemination in the web, being also used in computational approaches as pattern identification on polyphonic music [19]. Nevertheless, early music is almost completely overlooked in the repertoire presented in this digital format. As well as MIDI files, Finale files are also a standard format always more common in digital music libraries. However, again this format is popular in sharing codified scores from other 'classical' musical periods but not for Renaissance music. With this in mind, we included in the presented dataset MIDI and Finale files.

Beyond the symbolically codified files, a total of 180 pdf files have also been included. From these, 30 pdf are the modern notated transcriptions of the Finale encoded madrigals (to gain an easier evaluation of the repertoire). The other 150 pdf are scanned copies of the first edition of the original source (5 pdf files for each madrigal, one for each voice). In total, the SEILS dataset encompasses 330 files: 180 of them are pdf files; whereas the remaining 150 are symbolic files digitally encoded in different formats. Of these 150 symbolic files: 60 are encoded by Lilypond (.ly), 30 in each of the considered notations (early and modern); 30 are encoded by Music XML (.xml); 30 by MIDI (.mid); and 30 by Finale (.musx).

6. CONCLUSIONS

The presented dataset of codified scores aims to encourage automatic musical analysis in Renaissance music. Considering the strong connections between music and poetry of the chosen repertoire, the presented dataset is specifically suitable for creating synergies between musicology and linguistics. We present symbolically encoded scores of the *Il Lauro Secco* anthology considering the original *white mensural* early notation, which will allow for the evaluation of OMR performance.

Since each digital format has some advantages and disadvantages, it is our belief that through this combination, each limitation found in the formats can be overcome (e. g., by combining Lilypond and Music XML files, it is possible to clearly identify lyrics with musical patterns). With this in mind, the SEILS dataset makes available a variety of digital formats: Lilypond, Music XML, MIDI, and Finale.

Our next priority is to complete the analytic annotation of the presented dataset in **kern format, through the identification of different types of madrigalisms (e. g., based on contrapuntal and homorhythmic textures, or in consonant and dissonant vertical sonorities, among others), within each madrigal.

7. ACKNOWLEDGEMENT

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