Tools and Perspectives for a Digital Critical Edition of Fourteenth-Century Polyphonic Music[1]

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Abstract

The ERC funded project *European Ars Nova* aims to study the corpus of poetry in Latin, Italian and French set to music by the polyphonists of the so-called Ars Nova. Since one of the main research goals of the project is the comparative study of musical and poetic texts, we are currently developing a web application that will allow readers to visualize and interact with the TEI- and MEI-encoded editions of our corpus together. The adoption of MEI as the underlying format for the digital editions of the musical texts presented us with the challenge of designing an editing workflow that allowed us to critically edit the texts in a user-friendly software like Finale. In this article, we illustrate how the critical editions are transposed to MEI documents using an *ad hoc* tool developed within the project, and how they are visualized in the web application. Finally, we discuss the critical aspects of the workflow and possible next steps for our digital critical edition in relation to the state of the art of music encoding.

Introduction

The ERC funded project *European Ars Nova*[2] aims to study, through an interdisciplinary and comparative approach, the corpus of poetry in Latin, Italian and French set to music by the polyphonists of the so-called Ars Nova.

The project team is currently implementing the ArsNova Database, which intends to increase the basic resources and research instruments in this particular field of study. The database is also working as a VRE (virtual research environment) for the researchers on our team to share knowledge and ensure the reliability of their research results.

The ArsNova Database is hosted by MIRABILE, Digital Archives for Medieval Culture,[3] and consists of three sections:

- Catalogue of Ars Nova Manuscripts, Authors and Texts (CANT);
- Corpus of Poetic and Musical Texts (ANT);
- Repertory of Metrical and Musical Structures (ANS).

One of the goals of the *European Ars Nova* project is to offer online critical editions (of both poetic and musical texts) that may be used by the scientific community as a reference point. Since the comparative study of mu-

1 The research presented here is an integral part of the Advanced Grant project "European Ars Nova. Multilingual Poetry and Polyphonic Song in the Late Middle Ages". This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 786379). The work is the result of the collaboration between the three authors; specifically, §2 (except for §2.1) and §4 are contributed by Chiara Martignano, the introduction and §2.1 by Michele Epifani, §1 and §3 by Antonio Calvia.

2 https://www.europeanarsnova.eu/ (accessed January 12, 2022).

3 http://www.mirabileweb.it/ (accessed January 12, 2022).

sical and poetic texts is a central concern of the project, we plan to implement visualizations, through which the end user can read and interact with both the musical and the poetic texts. In the digital edition's graphic interface, musical and poetic texts will be juxtaposed, thus inviting readers to consult them together.

Within the ANT section, we are developing the digital edition of a selected subset of musical texts, starting with the works of Francesco degli Organi (Landini). We decided to base the digital editions of the musical texts on MEI encodings. We designed an editing workflow that allowed us to create the MEI encodings not manually, but programmatically. The goal of the editing workflow is to generate different outputs for both the printed and the digital edition. Setting up the digital edition required the use of external tools and the development of an *ad hoc* tool to transform the critical editions of the musical texts written in Finale into MEI-encoded documents.

In the next sections, we will specify some musicological and philological properties of the corpus of musical texts that will be part of the digital edition. Then, we will present our editing workflow together with the tools we have developed to: (a) assist the editors in the creation of scores encoded in MEI and (b) visualize the MEI files in a web application. Finally, we will discuss the critical aspects of the editorial workflow and the future perspectives for our digital edition.

1 Philological Aspects

The ANT corpus includes all secular polyphonic works in Italian, French, and Latin from 1309 to 1417 (about 1200 texts),[4] excluding the works of Guillaume de Machaut, for which a digital edition is currently in progress.[5] The texts, in comparison with other repertories, have a small manuscript tradition, mostly consisting of less than ten witnesses and lacking any autograph. The critical edition consists of a critical text (CrTe) written in common Western music notation (CMN) and an apparatus that shows the alternative readings (and the errors) found in the manuscripts and documents the editorial work.[6]

A selection of the corpus was chosen to prepare a sample of the digital critical edition. The selected sample includes Landini's two-voice and three-voice ballatas, a homogeneous repertoire large enough (over 140 pieces) to offer a sufficiently variegated spectrum of manuscript transmission possibilities, types of errors, and variant readings.

The CrTe will be offered in CMN, with the addition of the few signs traditionally used by scholars for "translating" some of the details of the fourteenth-century mensural systems, such as the brackets for the *ligaturae*.[7] The alternative readings will be offered both in CMN and in mensural notation, in two different apparatuses: the first one, a scholar-oriented critical apparatus (S-OCA), will present the alternative readings in mensural notation according to the consolidated editing practices of traditional printed editions; the second one, a performer-oriented critical apparatus (P-OCA), will provide a comparative view of all the alternative readings together with the "lemma"[8] in the form of score extracts in modern notation.

2 The Development of the Digital Edition

Before starting the implementation of the ANT digital edition, we conducted a study on the state of the art in digital music editions, in order to identify best practices and the tools currently available.

4 The chronological span of the corpus and the methodologies of the project are discussed in [7].

5 «The Works of Guillaume de Machaut: Music, Image, Text in the Middle Ages» (http://machaut.exeter.ac.uk, accessed January 12, 2022), project led by Yolanda Plumley.

6 Most of the Ars Nova repertoire's main collections are available online in high-quality digitizations or published in facsimile editions. See, for example, DIAMM (https://www.diamm.ac.uk) and the volumes published in the series Ars Nova (LIM). Access to digitizations and facsimiles reduces the need for diplomatic transcriptions, which should be limited to particular cases (e.g., the case of the difficult-to-read palimpsested folios of the San Lorenzo Codex [5]).

7 Our critical edition aims to restore as much as possible the meaning (and not the graphical appearance) of music written in mensural notation, and to this end it favours translation, a complex operation based on reading and understanding the source system.

8 In the present article, the term 'lemma' refers to critical reading in accordance with the definition of the <lem> element within the MEI guidelines (https://music-encoding.org/guidelines/v4/elements/lem.html, accessed January 12, 2022).

We decided to adopt MEI for three reasons:

1. the possibility of scholarly editing with MEI thanks to the `MEI.critapp` module[9] to create critical editions of the musical texts;
2. the availability of a tool like Verovio[10] [8] that allows to easily create dynamic and interactive scores from MEI files on a web page;
3. the use of MEI as a legacy format to preserve our digital editions in a non-proprietary format on the long term.

Once we decided to adopt MEI, we needed to find a solution that would help us encode the editions of the musical texts while reducing as much as possible the manual intervention in the encodings. The team that edits the musical texts consists of two musicologists and only one digital humanist. For this reason, it was vital to find a solution that allowed the musicologists to work autonomously on the musical editions.

We discarded MEI editors like MEISE, the DARIAH-DE MEI Score Editor web service,[11] and Meix.js[12] because they require the user to edit the MEI files directly in the XML code.[13]

Once the option of using an MEI editor was discarded, we searched for a solution to produce the editions entirely with a notation software and then convert the files to the MEI format. By using Sibelius, together with the SibMEI plugin[14], it would have been possible to export the files directly to MEI. However, most of the musical texts of our corpus had already been transcribed in Finale.[15]

We looked for a plugin that allowed us to edit the alternative readings of the musical texts in Finale. The CriticalEd [6], a tool developed at the Danish Centre for Music, does not seem to have been further developed in order to support Finale nor is it available to a general public.

2.1 The Philological Editing in Finale

As stated before, we opted for a two-fold critical apparatus, scholar- and performer-oriented. While the S-OCA consists of diplomatic transcriptions of the readings of a given witness, like in a traditional printed edition, the P-OCA will offer such readings translated into modern notation, allowing a friendly tool for performers with scarce familiarity with black mensural notation. We decided to transcribe the critical text in score format, according to the number of voices, adding a staff for each voice of each witness, including the 'manuscrit de surface' chosen as a reference point for formal and graphic readings.[16] Obviously, it is not necessary to transcribe each witness completely, but only when the readings diverge from the critical text.

In both apparatuses, we recorded the variant readings with respect to the following aspects: text underlay, pitch (including accidentals), durations, notation (mensuration signs, plicae, ligatures, color, rhythmic grouping, use of particular note-shapes, etc.). Therefore, the Finale document displays a synoptic edition, which records, along with the critical text, all the variant readings transmitted by the witnesses, including the 'manuscrit de surface', where it contains an error or a variant reading that the editor considers 'deterior'.[17]

9 https://music-encoding.org/guidelines/v4/content/scholarlyediting.html#critApp (accessed January 12, 2022).

10 https://www.verovio.org (accessed January 12, 2022).

11 https://meise.de.dariah.eu (accessed January 12, 2022).

12 GitHub repository of the editor Meix.js: https://github.com/DDMAL/meix.js (accessed January 12, 2022).

13 Although part of the critical apparatus, the S-OCA, as we will discuss below, provides a diplomatic transcription of the variant readings, the editor created by the Measuring Polyphony project [3] cannot be applied to our project for obvious reasons, since the material to be encoded belongs primarily to two radically different categories: on the one hand, items written in mensural notation; on the other hand, critical editions written in CMN.

14 GitHub repository of the plugin: https://github.com/music-encoding/sibmei (accessed January 12, 2022).

15 In any case, although the SibMEI plug-in saves a step in the conversion process in comparison to Finale, it introduces roughly the same issues that we shall discuss later.

16 For the notion of 'manuscrit de surface', see [2]. The choice of the 'manuscrit de surface' depends on various factors, among them the completeness of poetic and music texts, the importance of the manuscript within the tradition of a given composer, the correctness of the readings. In the case of Francesco Landini, we chose (whenever possible) the ms. Firenze, BNC, Panciatichi 26, which is the earliest and one of the most accurate extant witnesses for Landini's manuscript tradition.

17 It should be noted that something could be lost in the process of transcribing, since in many cases music notation allows more than one way to graphically represent the same meaning. The difference between two distinct notational systems in a composition (say, the post-Marchettan notation and the *Longanotation*) is virtually just a matter of graphic representation, but irrelevant for the substance of the musical text.

In the case of a two-voice ballata transmitted in a single witness, for example, we will have two staves for the CrTe and two staves for the transcription of the witness (WiTr), both in CMN. In this simple case, the WiTr will be different from the CrTe only for errors and other editorial elements, such as the editorial accidentals. Editing a three-voice composition preserved in three manuscripts requires twelve staves (three for the CrTe, and nine for each WiTrs). In other words, we have two sets of staves, one devoted to the CrTe, and a set of 'service' staves where the editor recorded the *varia lectio*, each labeled with the combination of the manuscript *siglum* and the voice part (for example, SqCt = *Squarcialupi Codex*, Contratenor part). As an example, Figure 1 shows the transcription of the three-voice ballata "Gentil aspetto, in cu' la mente mia" by Francesco Landini.

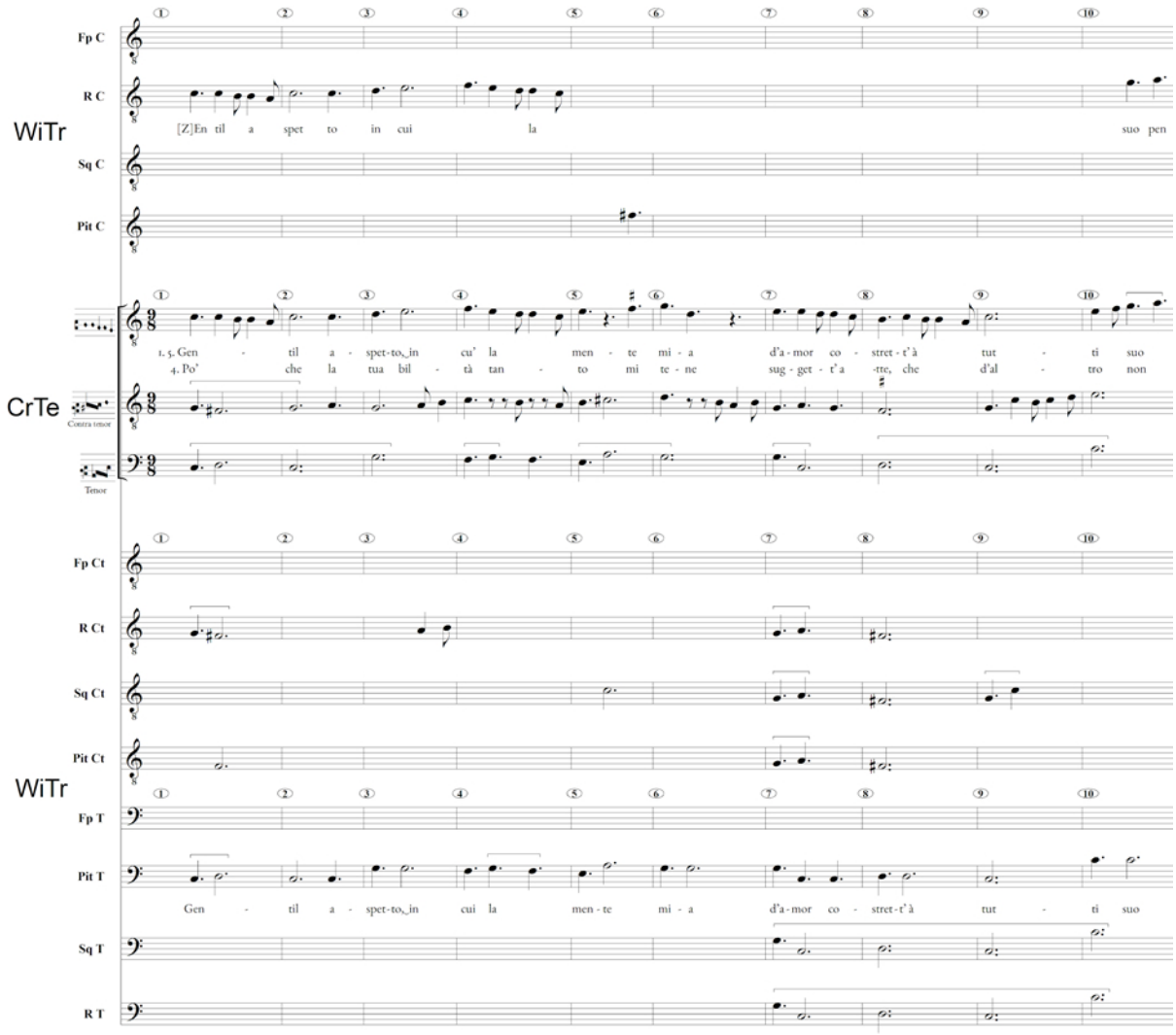

Figure 1: Transcriptions in Finale of the critical text and the witnesses of Francesco Landini's "Gentil aspetto", mm. 1–10.

In this case, one of the witnesses (Pit) needs a separate edition, since the Tenor part (staff "Pit T") bears the text, thus configuring an alternative version of the work. This type of variant reading, which might be considered an extreme case of text underlay variance, necessarily involves the vocal/instrumental (or vocal/vocalized) dichotomy; in all likelihood, it originated from medieval performance practice and affects the modern performance too.[18]

To sum up, the CrTe is entirely transcribed in the Finale document, while each WiTr is written only where it differentiates from the CrTe, thus producing one complete CrTe and as many "negative" WiTrs as the number

18 In similar cases, the possibility to identify one of the versions as 'correct' or 'better' than the others is scarce. If, as in the majority of the cases, there is no way to determine what the author wanted, there will be no way to determine whether the text is missing (by accident or deliberately) or was added later. On the other hand, each version is essential for the history of the reception of the work.

of the witnesses. After the 'synoptic edition' is completed, each of the 'service' staves – corresponding to the WiTrs – and the CrTe are exported as individual MusicXML files using the "Extract parts" tool in Finale. The MusicXML files are then converted to MEI with the MusicXML Converter tool of Verovio[19]. Finally, all the MEI files are merged into one MEI document with the tool ANTCollator developed within the *European Ars Nova* project. The final result of the workflow is a MEI-encoded critical edition, ready to be visualized on a web page. Before presenting how the editions are visualized, we will introduce the ANTCollator software.

2.2 The Merging Process with the ANTCollator Software

Since the result of the philological collation carried out by the critical editor is a Finale file containing the CrTe and all the "negative" WiTrs in separate staves, we needed a software to reassemble all this information in the form of a MEI-encoded critical edition.

The ANTCollator[20] is an application, developed with the javascript framework Angular[21], that compares a main MEI file containing the CrTe, used as the "base text" of the collation, with multiple MEI files containing the WiTrs.[22]

By default, the name of a WiTr file is used as its *siglum*. For example, if the text of the witness Ab is stored in the file "Ab.mei", the software will extract "Ab" from the file name and use it as identifier of the WiTr. The user can manually change the *siglum* of each witness.

The collation parser is, for the moment, rather basic: it compares the CrTe with a WiTr at a time and measure by measure. When the measure of the CrTe and the measure of the WiTr differ, the measure of the WiTr and the *siglum* of the witness are stored in a JSON object. This JSON object models the critical apparatus and all the other main information about the critical edition. Then, all the readings registered in the model are embedded as MEI elements in the output file. The output file is a duplicate of the base file that features `<app>` elements in correspondence of the measures subject to variation. Inside the `<app>` elements, the "lemma", which is the measure of the CrTe, marked up as `<lem>`, and the measures with alternative readings of the WiTrs, marked up as `<rdg>`, are nested. The software outputs the merged MEI file and the JSON model.

The `<app>` elements derived from the automatic comparison are the base for the P-OCA. We decided to implement also the S-OCA of each edition inside of the respective collated MEI file. In this way, one MEI file corresponds to the complete digital edition of a musical text. In order to facilitate the encoding of the critical entries of this apparatus, a dedicated module of the ANTCollator software was developed. Thanks to this module, the editors can add, edit, and remove critical entries from the apparatus. Each entry must be anchored to a measure by its number, so that on the web page the readers will be able to go from the score to the apparatus and vice versa. The text of the entries can be edited in a text area input with the help of a SMuFL[23] characters keyboard to reproduce the alternative readings in mensural notation. The S-OCA and its entries are dynamically stored in the JSON model and also added to the output MEI file as MEI elements. The apparatus is converted into a `<list>`, which is inserted into a generic `<div>` appended to the `<music>` element. The entries are transformed into `<li>` elements, which contain their texts and the SMuFL characters as `<symbol>` elements. The number of the measure is stored in the @n attribute of the `<li>` element (see Listing 1).

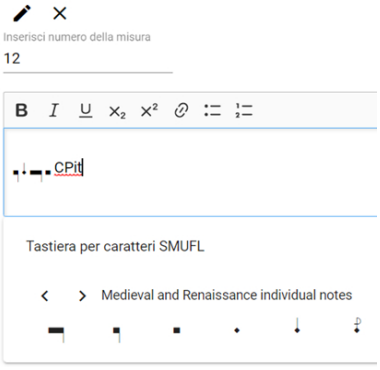

Figure 2: The section of the ANTCollator to edit the S-OCA with the help of a SMuFL characters keyboard.

19 https://www.verovio.org/musicxml.html (accessed January 12, 2022).

20 The software was named "collator" because, although the underlying collating algorithm is for the moment rather basic, it can be used to automatically compare a base text with multiple WiTrs encoded in MEI. In our editorial workflow, we use the ANTCollator not as an automatic collator but as a post-collation tool to merge the MEI files of the CrTE and of the WiTrs in one MEI file, to edit the S-OCA and the file metadata, and to create a JSON model that will be used in the ANTViewer.

21 https://angular.io (accessed January 12, 2022).

22 There are other tools available to carry out the automatic comparison of different MEI files, for example MusicDiff [4] (https://music-diff.edirom.de/, accessed January 12, 2022); we decided, however, not to use MusicDiff and to develop from scratch a tool that could perform both a simple file comparison and the MEI encoding of custom data.

23 https://www.smufl.org (accessed January 12, 2022).

Because the S-OCA is meant to be visualized as plain text, like in a printed edition, we opted for a light-weight markup solution using SMuFL characters.

```
<div>
  <list>
    <head>Scholar-Oriented Critical Apparatus Entries</head>
    <li n="MeasureNumber">
    <!-- if necessary, a secondary list for each single variant -->
      <symbol glyph.num="U+E958"></symbol>
      <!-- SMuFL character for the mensural notation readings -->
      <!-- Witness Siglum -->
    </li>
  </list>
</div>
```

Listing 1: A sample encoding of the scholar-oriented critical apparatus (S-OCA).

Finally, the ANTCollator software is constituted also by a module that helps encoding the metadata of the MEI file, like the title of the musical text and its author, the names of the critical editors, etc. The data inserted by the editors are then converted into MEI elements and added to the `<meiHead>`.

2.3 The Visualization of the Digital Editions

The digital editions are visualized in a web application called ANTViewer, developed in Angular. The digital editions will be integrated in the same digital archive of medieval culture, "Mirabile", that hosts the catalogue (CANT) and the metric repertory (ANS) of our project.

The editions of the musical texts are available inside the GUI both individually and in a comparative view together with the poetic texts.

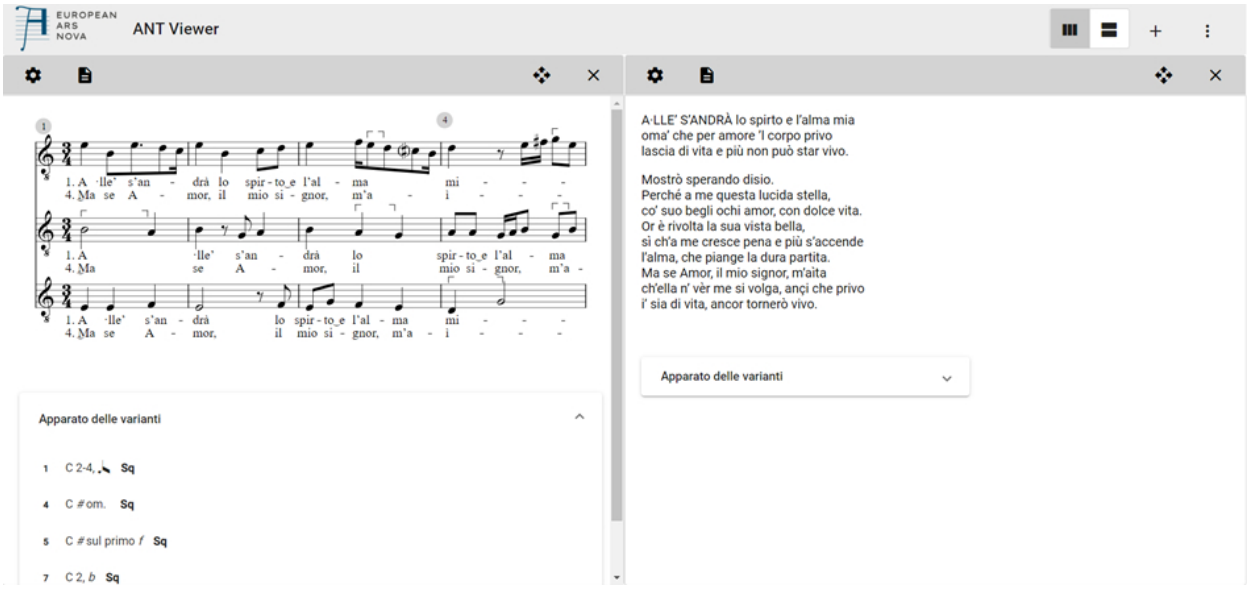

Figure 3: Comparative view of the musical and poetic texts in the ANTViewer.

The scores of the editions are rendered on the web page with Verovio. Thanks to the Verovio javascript toolkit, it is possible to interact with the score: browsing by page, changing the zoom level, and handling the layout and the score breaks. In some digital edition projects, like Measuring Polyphony and Tasso in Music[24], it is possible to switch the score from modern to mensural notation. We decided not to implement this feature in our

24 "Tasso in Music Project", https://www.tassomusic.org/ (accessed January 12, 2022).

edition, but to present the critical texts in modern notation only. However, as mentioned above, readers are offered two different apparatuses (S-OCA and P-OCA).

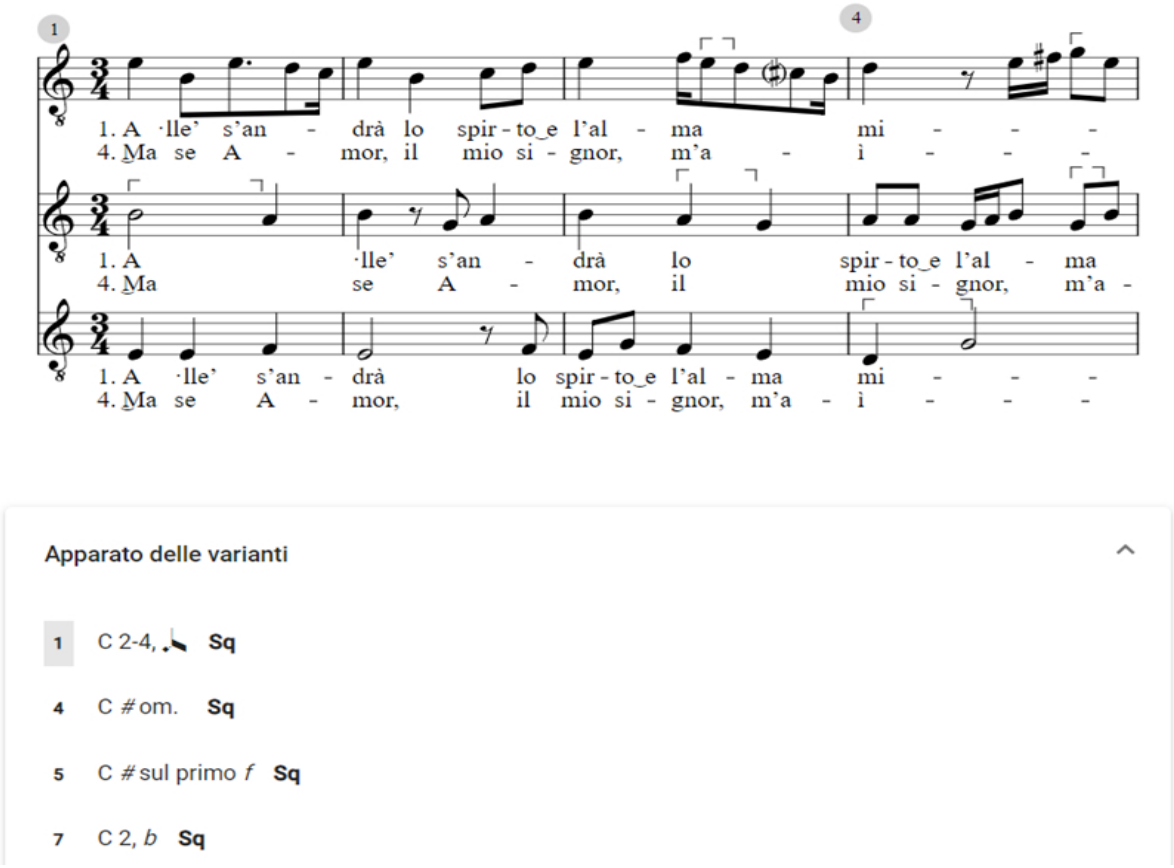

Figure 4: Rendering of the S-OCA in the ANTViewer.

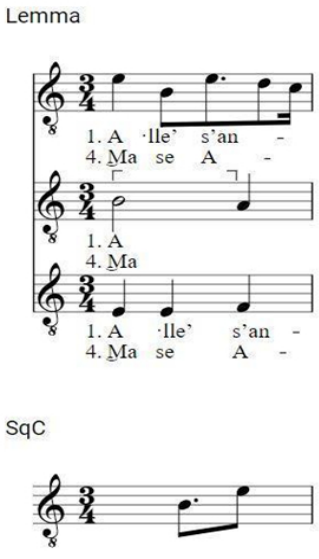

Figure 5: Rendering of the P-OCA in the ANTViewer.

The S-OCA is always visible in a panel below the critical text score. This panel displays all the critical entries together, allowing the user to scroll through them and get an overview of the variation of the text in the tradition. Each entry is preceded by the number of the measure it refers to. By clicking on the number, the corresponding measure is loaded into the score, if not yet visible, and highlighted.

In the score, the presence of a *locus criticus* for a given measure is indicated by an icon placed above the measure that displays the measure number. The icons of the *loci critici* trigger the opening of the two apparatuses depending on the option selected by the user. The option is set by default to "traditional mode": When the user clicks on an icon, the S-OCA panel is opened and scrolled to the corresponding critical entry for the measure. When the option is set to "collation mode", the P-OCA is loaded as a new panel on top of the critical text. In that apparatus, the reader can find in a comparative view the critical text and the witnesses. All the score extracts are given in modern notation.

3 Problems and Critical Aspects

The critical aspects of the workflow outlined above are manifold. As mentioned before, the texts in our corpus have few witnesses, therefore we can afford to create the files and edit the witnesses for each single edition. For an edition based on a larger number of witnesses, the editing phase with Finale would not be sustainable.

Writing with a user-friendly graphical interface, such as that of Finale, Sibelius, or other music writing softwares, remains an essential asset for the critical editing of music. At the same time, encoding in MEI provides clear advantages, above all in terms of interoperability and long-term preservation.

Some of the problems of the editorial workflow that still need to be solved are purely graphic. The conversion of edition files between different formats (from Finale's proprietary format to MusicXML, from MusicXML to MEI, and from MEI to SVG) results in considerable loss of graphic information. The difference between the score visualized in the web application with Verovio and the score edited in Finale is quite significant.

We offer here a few examples of the graphical problems: 1) brackets to represent *ligaturae*; 2) editorial accidentals; 3) encoding of *synaloepha* and *aphaeresis*; 4) nonstandard notational elements involved in the translation from mensural to current notational systems (double-dotted half notes and conflicting and/or nonstandard key signatures).

The use of brackets to represent the *ligaturae* of mensural notation is widespread in editorial practice. However, following the procedure described above for the conversion from a Finale file to an MEI file, the brackets are not encoded (Figure 6):

```
<measure n="3" xml:id="w29756ab1c17">
   <staff n="1">
      <layer n="1">
         <note dur="8" [11 lines]
         <note dur="4" [4 lines]
         <note dur="4" [11 lines]
         <note dur="8" [4 lines]
      </layer>
   </staff>
   <staff n="2">
      <layer n="1">
         <note dur="4" [11 lines]
         <note dur="4" [11 lines]
         <note dur="4" [4 lines]
      </layer>
   </staff>
   <!--Bracket not transcoded.-->
```

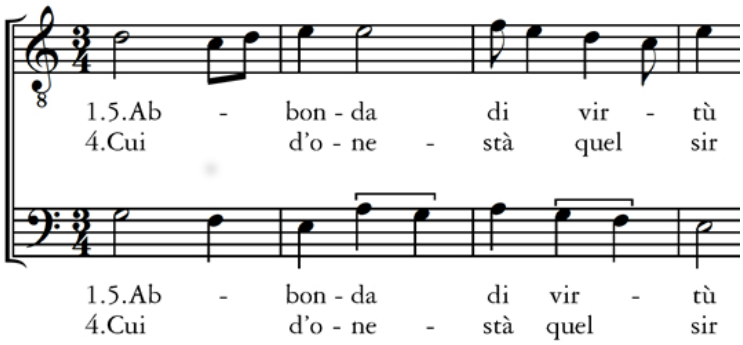

Figure 6: Francesco Landini, "Abbonda di virtù", MEI encoding of m. 3 compared to the rendering of the Finale file.

Entering *ligaturae* as a slur in Finale, however, allows us to encode in MEI the position of the beginning and end of the graphic sign, to which we then apply a different rendering.

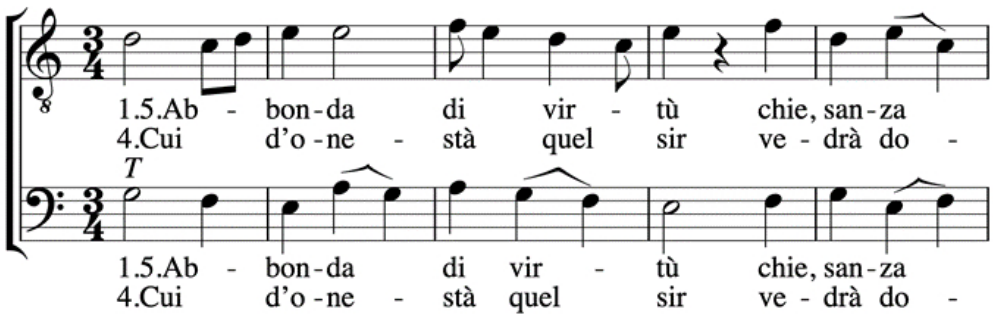

Figure 7: Rendering of the *ligaturae* in Verovio.

The issue of editorial accidentals is addressed in the MEI Guidelines from the point of view of semantic markup. Our project would need a semantic marker "editorial" for an accidental to be associated with a particular

graphical rendering that allows one to recognize an "editorial" accidental at first glance. For example, the most common choice in paper editions, as is well known, is to place the accidental above the note. However, in a digital edition other graphic options can be found (colour, size, font).

We have encountered some problems in encoding the *synaloepha* in the transition from Finale, where a "hard space" is typically used, to MEI. In such cases we intervene directly with the Oxygen XML Editor[25] to modify the affected syllable.

The problems concerning the rendering of the critical text and of the critical apparatus are the same. Generally, the results that can be obtained by using Finale in a 'crafty' way do not work in a different environment. A single example will suffice: "Gentil aspetto" is in *tempus perfectum maius*, and one may want to use the double- dotted half note introduced by Willi Apel [1] in order to transcribe a single brevis with a single note worth nine eighths. Such a note value does not exist in standard music notation as a single note-shape, hence the *nonstandard* double dot (see, for instance, the first two bars of Figure 8).[26]

Another issue concerns key signatures. In editions of fourteenth-century music, it may be necessary to represent both conflicting signatures (for example, the Tenor part with b-flat, the upper parts with no accidentals) and nonstandard placement (typically, one may want to place the b-flat in the bass clef an octave higher than usual). "Gentil aspetto" presents both issues: In one of the witnesses (Pit), the B section of the Tenor part alone contains two flats, b and e, with b an octave higher.

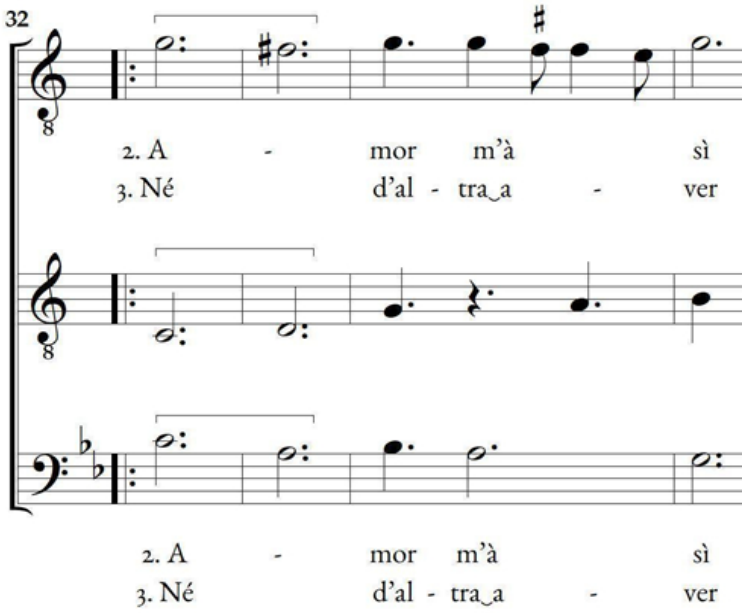

Figure 8: Francesco Landini, "Gentil aspetto" (alternative version), CrTe, mm. 32–34.

Unfortunately, to achieve this result with Finale, it is necessary to configure the key signature not only as an independent element of the staff but also as a *nonstandard* signature to display the b-flat one octave higher than usual in the bass clef. The uncommon placement of the key accidentals is not recorded in the MusicXML file,[27] while in the MEI-transcoded file the change of key signature is entirely neglected. This problem arises even when a standard key signature is assigned as an independent element of the staff.[28]

25 http://www.oxygenxml.com (accessed January 12, 2022).

26 In this case, the double augmentation dot acquires a different meaning than in standard modern notation, which is why Apel places the dots on top of each other [:], and not in the standard way [..].

27 Even when importing the generated MusicXML file with Finale itself, the signature accidentals appear in the default octave setting.

28 It seems that the key signature of the first staff invariably affects all the others; putting a b-flat on the Cantus part, no flats in the Contratenor part, and two flats on the Tenor staff, the conversion from MusicXML to MEI generates a file with a b-flat on all staves.

4 Conclusions and Future Perspectives

The workflow described has different limitations concerning the final rendering of the scores on the web page and the ability of transcoding what one sees in the Finale interface into appropriate MEI encodings. The current workflow requires some tweaks when editing with Finale and a manual review of the MEI files. An "MEI-centric" approach, i.e., a workflow that starts from the MEI-encoding of the editions, would likely have resulted in the creation of only one MEI file that could have been used, without further intervention, as a starting point for both the digital and printed editions. In this case, the online and printed versions of the scores might have been visually more consistent.

The limitations of our workflow are representative of two problems with digital editing of music. On the one hand, the lack of WYSIWYG[29] tools for encoding in MEI. The currently available editing tools we know require music encoding skills. On the other hand, editors need significant computer science skills, in order to have a higher control over the rendering of the edition on the web page.

In the broader context of the focus of our research project, the implementation of the digital critical edition of the ANT represents an auxiliary task for the moment and is meant to test our corpus with the possibilities offered by the digital medium. The possible next steps for our digital critical edition, once we have refined the editing workflow, are: 1) extending the subset of our corpus that will be available in the digital edition; 2) grant open access to the MEI encodings in the long term by storing them in an online repository. Our hope for the future is to be able to encode the whole ANT corpus in MEI and preserve it in an interoperable format so that it may be used for further innovative studies.

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29 Acronym for "What you see is what you get", used to describe editing software that allows content to be edited in a form that resembles its final appearance when printed or displayed on a web page.