New Digital Strategies for Creating and Comparing the Content Structure of Biblical Manuscripts

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Abstract
In an era when more and more manuscript scholarship is taking place on the internet, through digital manuscripts, databases and electronic publishing, there is a corresponding and growing need among scholars for flexible and creative ways to create clear and coherent online manuscript descriptions. This article presents a prototype of a tool, currently under development at the Ludwig Maximilian University of Munich, which aims to streamline the description process to facilitate comparisons between manuscripts from different cultural areas. Presently, the tool is being developed for use with biblical manuscripts and the article outlines the challenges that come with creating and comparing this kind of material, which is often similar in terms of content but very diverse as to its structure. It then offers solutions that allow users to describe and compare the manuscripts at differing levels of granularity. Lastly, the article sets forth a pattern of use that could be transposed onto areas of manuscript studies beyond biblical manuscripts and offers perspectives for the tool's wider application.

INTRODUCTION

With the growing interest in manuscript studies and the rapidly increasing amount of electronic manuscript facsimiles available online, there is also a growing need for a new generation of databases that allow a large public of scholars, students and the simply curious to visualize and work with manuscript data in different and flexible ways.[1] As discussed in a previous article, an area which requires particular improvement concerns the ability to efficiently compare the content of different manuscripts.[2]

This article presents a prototype of a tool that facilitates such comparisons, which is currently under development at the Ludwig-Maximilian University, Munich in the framework of a planned project in the realm of manuscript studies. The tool's focus is to create entries for all

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[1] For previous articles on this subject, see Andrist, 2021a especially §2 and Andrist, 2021b.
[2] Andrist, 2021a, cf. §4.

of a manuscript's biblical content in a few clicks. It structures the data for easy comparison with biblical content in manuscripts from different cultural areas,[3] at several levels of granularity, despite varying traditions concerning the names and the groupings of the biblical books.[4]

The prototype's aim is to test the tool's basic functionality and round out the database's underlying data model. The tool's visualization aspects and its user-facing side will be created in a later phase of development, in collaboration with future users. First, we present some peculiarities of the content found in biblical manuscripts. Then, we will survey the main challenges facing the development and use of this tool and discuss some aspects of its underlying data model.

VARYING TRADITIONS OF GROUPING AND NAMING BIBLICAL BOOKS IN BIBLICAL MANUSCRIPTS

We define biblical manuscripts as manuscript codices or scrolls whose content mainly consists of biblical books and paracontents (paratexts)[5] to biblical books. Standard biblical manuscripts can be divided into several classes:

- 1: Manuscripts in which the biblical books are situated one after the other in a more or less canonical sequence. These manuscripts reflect the direct transmission of the biblical text. They are often accompanied by a rich corpus of paracontents and are sometimes framed by a dense web of commentaries.

- 2: Manuscripts in which the biblical text is portioned into pericopes that are organized according to a liturgical reading order.

- 3: Biblical scholars often include commentaries in which quotes from the biblical text alternate with explanations by one or several authors in this category of biblical manuscripts. These manuscripts can certainly be important witnesses to the biblical text, and, as such, are also studied by biblical scholars. Nevertheless, they are distinct from the previous two groups both in terms of layout and content and their status as biblical manuscripts is problematic from a book-historical point of view, since the biblical text is indirectly transmitted by a commentator.

In the first stage of our project, we will concentrate on manuscripts of the first group, copied in codex book-form. We hope to deal with the second group at a later stage.

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[3] In the current state of the project, we plan to gather data from Greek, Coptic, Armenian, Arabic and Ethiopian biblical manuscripts. We also hope to collaborate with external projects on Latin Bibles. The collected data will be available through a public interface in open access, including import and export possibilities with other databases through APIs. In the long term, the data will be stored in the research data repositorium of the University Library of the LMU.

[4] The prototype is developed in collaboration with the IT-Gruppe Geisteswissenschaften of the LMU. It is mainly written in JavaScript, with WordPress additionally used as CMS for page management. To ensure the responsiveness of the tool, a Bootstrap5-based WordPress theme is used. All data is managed in a relational MySQL database, which is accessed via a JSON API written in PHP.

[5] We use the word « Paratexts » for textual paracontents only, Andrist 2022, 216.

A biblical manuscript usually contains several biblical books, but there are some exceptions, such as the Christian Psalter and the Jewish Megillot.[6] In most ancient cultural traditions, however, there are few surviving manuscripts which contain the whole of the Christian Bible (these also named pandects), or even the entire Old Testament or New Testament (OT or NT pandects). More common are manuscripts which contain one (or more) ensembles of biblical books—that is to say—groupings in which biblical books traditionally circulated (we will return to this in the discussion below), which are also often designated as "sections" of the corresponding biblical canon.

In the Christian Greek tradition, for example, the most common manuscript groupings of New Testament books are, on the one hand, *tetraevangelia* containing the four Gospels and, on the other, *praxapostoloi*, which can also be broken up into three further sub-groups, the Acts of the Apostles, the Catholic Epistles and the Pauline Epistles, which are also three traditional ensembles; they are often (but not necessarily) accompanied by the Apocalypse of John.

Even within one cultural tradition, both the order of the ensembles and the order of the books within some of these ensembles can vary from manuscript to manuscript. In the Latin medieval tradition, for example, there are at least three competing major orders for the biblical books, with many smaller variations amounting to at least 72 possibilities.[7] An added layer of complexity is introduced when comparing different traditions, as not all traditions recognize the same books as canonical. In the Jewish Bible (=TaNaKh), for instance, there are 35 books[8] organized into three ensembles, while in copies of the corresponding Christian Old Testament, there are frequently four ensembles which usually amount to between 50 and 55 books (including the so-called deuterocanonical books), as further explained below. In the Ethiopian tradition, the concept of canon is understood differently and the books which may be found in biblical manuscripts are more numerous.[9]

These differences in what texts are considered canonical and how such texts are organized in different cultural traditions raises a series of challenging situations, some of which are presented here.

I CHALLENGE 1: ACCOMMODATING FLUIDITY IN NAMING PRACTICES ACROSS DIFFERENT CULTURES WITHOUT INTRODUCING AMBIGUITY

The first challenge is not to repeat the same name (or the same internal ID) for two different biblical books or ensembles, despite contradictory usages in different cultural areas. For a few specific books or ensembles, the risk for such a confusion is significant.

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[6] The Psalter is a book containing the biblical psalms as its main content, sometimes also with hymns, prayers etc. The Megillot are the five Jewish scrolls each containing a relatively short biblical book, which is read at the synagogue once a year.
[7] Ruzzier, 2022.
[8] Counting the Twelve Prophets individually; traditionally, these are counted as one, and the total is twenty-four books.
[9] Brandt, 2003; Abraha, 2017.

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For example, the separate books which are known as Ezra and Nehemiah today, used to be copied as a single book in ancient Hebrew manuscripts, under the name of Esdras, and in the Septuagint[10] under the name of B Esdras. The Septuagint however also contains a second book of Esdras, named A Esdras in the manuscripts.[11] In the Latin tradition, however, what is known as the book of Ezra today is called I Esdras, Nehemiah is II Esdras, A Esdras is III Esdras, and there is also an apocalyptic IV Esdras absent from the Greek and Hebrew traditions. In some Latin manuscripts, however, Nehemiah is also designated as Nehemiah and A Esdras… as II Esdras (instead of III Esdras). To avoid this kind of confusion, we created an internal list of the biblical books (in Latin, according to the philological tradition, see Appendix), for the project, which puts a name in relation to a piece of content. As a result, there are cases where the book will be described with a name such as "II Esdras" = III Esdras, and correctly linked with the internal III Esdras.

The reverse situation is less problematic: to continue with the previous example, if some people describe a book as Nehemiah instead of II Esdras, the system can tolerate this, as long as there is a non-ambiguous relationship with one reference name. This implies that the system is able to differentiate between the names given in a manuscript and standardized internal book names. But there is still a problem: how should one designate the books of Esdras and Nehemiah in a manuscript where they are copied as two distinct pieces of content, with the intention of comparing this manuscript with another one in which they are grouped together as a single piece of content (B Esdras, for example)? In this case, the problem has to do with what is included in the biblical books of the manuscript rather than diverging or ambiguous names. If they are described as one biblical item, the description does not reflect the reality of the manuscript. But if they are described as two items (as in the manuscript), it is more difficult to use them for comparison with manuscripts where they are transmitted as one piece (unless this piece is described in two items, contrary to its actual arrangement in the manuscript).

One solution would be to oblige the describers to use one convention or the other and inform readers about any divergences from the manuscript in the notes. We prefer, however, to observe the divisions in the manuscript and to create an intermediate "research level" for technical purposes, which does not strictly reflect book names, but in which one or more book names are transformed into "content zones". The relation of these zones to book names is generally not one-to-one, so that (for example) all the variants for the Esdras material are grouped together as a single "zEsdras" zone (see also Table 2 below). This gives users the possibility to do a search either at the more inclusive level of zones or at the more selective level of book names. As explained below, these zones are automatically generated if users do not want to bother with them. As for book names (and for similar reasons), the displayed zone names can be different from the internal zone name.

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[10] The Septuagint is a pre-Christian Greek translation of the Jewish Bible, including some "deuterocanonical" books that are not in the Hebrew Canon. For a complete edition, see Rahlfs Hanhart, 2006. See also Kreuzer, 2016 and its English translation, Kreuzer, 2019. About the traditional ensembles of the Septuagint (understood as sections of the Canon) in relation to the Hebrew ensembles, see Tov, 2016.
[11] See, for example Bogaert, 2000.

II CHALLENGE 2: SURVEYING A REPRESENTATIVE NUMBER OF MANUSCRIPTS IN AN EFFICIENT WAY

2.1 Devising a powerful and structured system to create biblical content in a manuscript description

Some biblical traditions —the Greek tradition in particular—have been studied by scholars for generations. There are specialized research centres which identify and number all the biblical manuscripts written in Greek, and the contents of most of these manuscripts have been sketched out or described, often in digital form.[12] As a result, the nature and extent of the preserved manuscripts in these traditions are fairly well known. In other cases, such as in the Arabic tradition, there is no complete picture of how many biblical manuscripts exist.[13] The first challenge for our colleagues working with these manuscripts is to make an inventory and give a summary idea of their content.

In our Prototype, we take advantage of the previously mentioned traditional circulation of biblical books in ensembles in order to let users create all biblical content items with a few clicks.

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[12] Reference numbers and basic content description for Greek New Testament manuscripts are provided by the Institut für neutestamentliche Textforschung in Münster, on their website: https://ntvmr.uni-muenster.de/ (last accessed 04.09.2023). For the Old Testament, see Rahlfs, 1914; partially updated in Rahlfs Fraenkel, 2004.
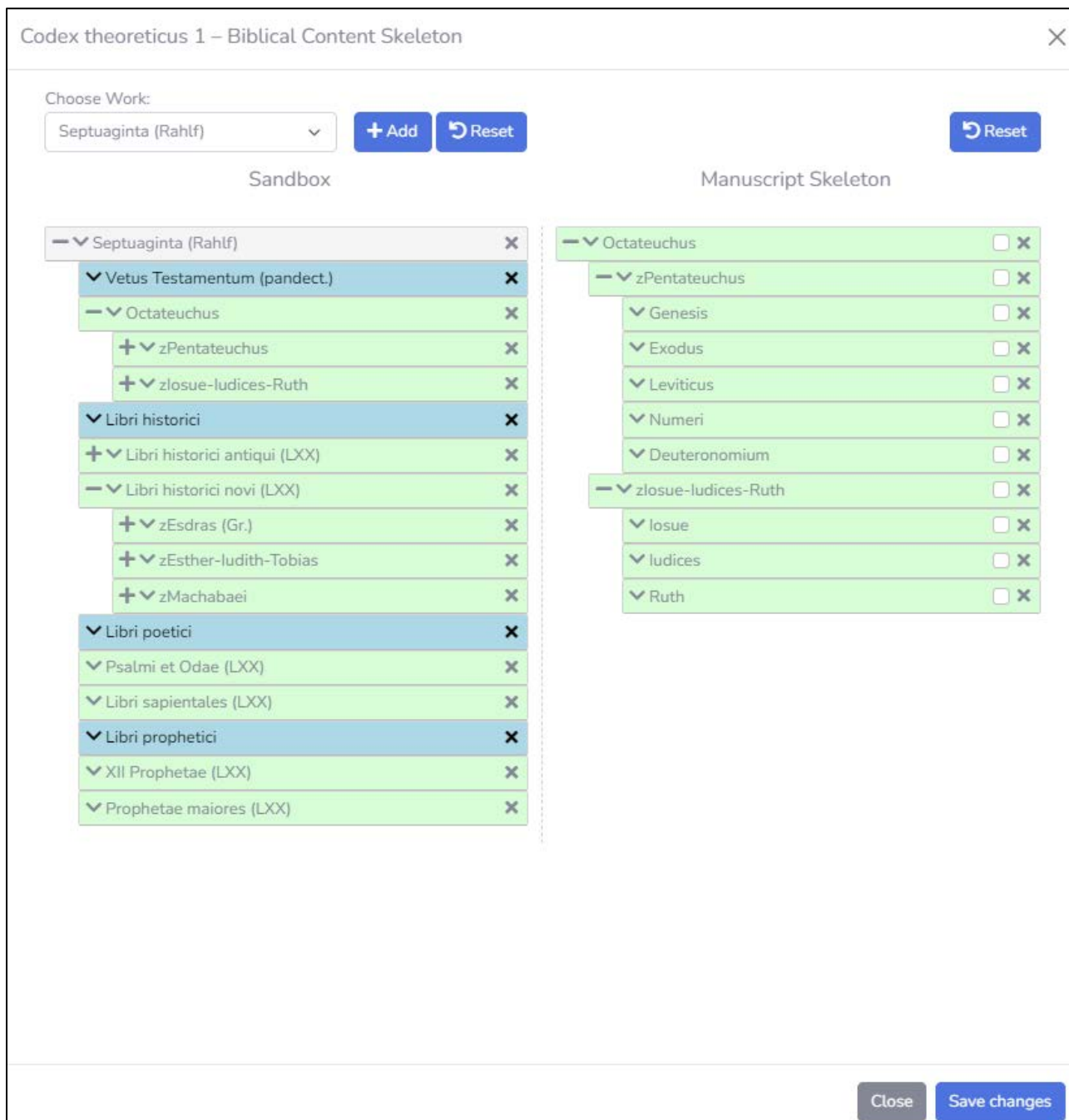[13] See Vollandt, 2018.

Table 1: illustration of the workspace, with the example of the Octateuch.

As illustrated in Table 1, the tool's workspace is divided into two areas with a drop-down menu at the top: the area on the left is a sandbox, or a working area; the area on the right is the skeleton, which reflects the current biblical content of the manuscript being described.

- In the drop-down menu, users choose which part of the Bible and/or which cultural tradition they want to work with, and the system lists all the traditional ensembles belonging to this tradition in the left part of the screen. They can then move the items up and down or remove

them. If they open them with the + sign, the level of the zones or the actual books themselves are displayed.

- From there, every item in green, including all the items underneath (if any), can be dragged to the right part of the screen.[14] For example, if users are working with the Christian Old Testament, they can drag the entry "Octateuchus" from left to right, where eleven items are immediately created: one for the ensemble, two for the zones and eight for the books making up the Octateuch. Also on this right panel, users can modify the order of the books, the zones or the ensembles and remove them.

- If, however, a blue item (such as Biblia Christiana, Vetus Testamentum, or Biblici historici) is moved to the right, only one corresponding item is created, without any underneath items.

- If they then click on the button "save changes", all the items on the right are also created in the corresponding manuscript description in the same sequence. Page or folio numbers (or other peculiarities of these entries) can be added in the content description area of the interface at any time.

- If users are not satisfied with the description of the biblical content after they have saved it and closed the window, they can display the skeleton again in the workspace as they saved it and modify it.

The power of the tool becomes clear if one considers that a complete Old Testament can be created at once with a few moves of the mouse. In an earlier version of the prototype, it was even possible to create a complete Old Testament including all the items underneath, just by moving the single item "Vetus Testamentum" to the right. There are, however, too many underlying content variables and this created a significant risk that the book items created with a single click on the right would not correspond to the reality of the manuscript. This is why we limit this option only for more compact traditional ensembles.[15] But even with this restriction, a complete Septuagint Old Testament can be created by moving the following seven items "Octateuchus", "Libri historici antiqui (LXX)", "Libri historici novi (LXX)", "Psalmi et Odae (LXX)", "Libri sapientales (LXX)", "XII Prophetae (LXX)", "Prophetae maiores (LXX)" to the right.

If, however, users do not have enough time to check all the items which make up a "green" ensemble or zone, they can also temporarily make them blue and move them to the right. As a result, only the ensemble or zone name is created in the skeleton, without the underlying items. If, for example, they notice that the ensemble of the four "Major Prophets" is in the manuscript but cannot check whether the smaller books in the corpus of Jeremiah and Daniel are also present, they can just turn the item "Prophetae maiores (LXX)" blue and drag it to the right and only one item will be created. Even these undetailed descriptions of the content can be used for interesting comparisons, and we will also give users the possibility to make Biblical content

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[14] For the time being, the checkboxes in the right panel are not used. For people with difficulties in colour perception, we are planning to automatically add a symbol on the line after the Biblical name to inform them what kind of item it is.

[15] As explained above, it is still possible to move "Vetus Testamentum" to the right, but, in this case, only one first level item is created (see below §2.3).

comparisons at this more "superficial" level. In the future, incompletely described manuscripts should also be flagged in order to be immediately recognized or identifiable in searches.

2.2 Solutions to a number of complex situations

This multi-level approach, however, creates several supplementary challenges:
Firstly, the name and delimitations of the ensembles vary from one cultural area to the next. For example, as mentioned above, the TaNaKh is traditionally divided into three main ensembles:[16]
- the Torah (the Teachings);
- the Nevi'im (the Prophets), further divided into the Former Prophets, the Latter Prophets, which are also divided into the Major Prophets and the Twelve Minor Prophets;
- the Ketuvim (the Writings), further divided into the Poetic Books, the Five Scrolls, and the other books, which do not constitute a sub-ensemble in the strict sense.

In the Christian traditions of Antiquity and the Middle Ages (as evidenced in part in the manuscript tradition) however, the structure of the Old Testament as organized in ensembles is not as systematic as in the TaNaKh. There is, however, a frequent grouping in four ensembles:
- the first books of the Bible can be assembled as a "Pentateuch", "Heptateuch" or "Octateuch", depending on whether they contained the five, seven or eight first books;[17]
- they are usually followed by the Historical Books, possibly divided into the Ancient Historians (Historici antiqui) and the Recent Historians (Historici novi) and sometimes even the Very Recent Historians (Historici novissimi); some even include the Pentateuch as a subdivision of the Historical books;
- the Prophetic books, divided into the Twelve (or Minor) Prophets and Four (or Major) Prophets (including some "canonical paratexts", such as the Lamentation of Jeremiah);
- the Poetic books, with the Psalms and the Odes in one sub-ensemble, and the Books of Wisdom (Sapientes) making another one.

As a result, books such as Joshua and Judges are diversely included in the former Prophets (in the Hebrew tradition), in the Octateuch, or in the Ancient Historians (in Christian traditions whose first ensemble is the Pentateuch).

One way to deal with this challenge would be, again, to impose a standard set of ensembles and ensemble names, no matter which tradition is used. This solution, however, would likely be met with resistance from cataloguers when confronted with a taxonomy alien to their habits and tradition and increase the likelihood of errors being introduced during the description process.

Moreover, these descriptions would convey a false picture of the manuscripts, especially if their presentation of the ensemble did not correspond to the reality of the manuscript.

Here again, the intermediary technical "zone level" described above allows users to bypass this problem: we provide users with ensemble names corresponding to their traditions, but the system adds an intermediate series of more rigidly defined content zones.

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[16] See Barton, 2013, 145–164.
[17] See Bogaert, 1997, 313–337.

For example: in the Syriac tradition the four Gospels are sometimes replaced by Tatian's *Diatessaron*.[18] If, in both cases, they are described as zEvangelia at the zone level, a comparison between them (at this level) will consider them equivalent.

As a second example, let us consider the first books of the Bible:

- one user working with a Hebrew manuscript may describe its beginning as "Pentateuch", then "Former Prophets" etc.: this will result in the following zones:
"zPentateuchus", "zIosue-Iudices-Ruth", "zSamuelis-Regum" (according to their internal names).[19]

- while, another one working with a Greek manuscript, may opt for "Octateuch" and "Propheti Antiqui", etc. this will result in the following zones:
"zPentateuchus", "zIosue-Iudices-Ruth", "zSamuelis-Regum", "zChronicorum".

As a result, both series begin with the same sequence.

Another challenge has to do with the fact that even though users may not have time to check the presence of each book name, they may need a more granular grouping of books than the traditional ensembles or sub-ensembles. This occurs, for example, when a traditional ensemble is split in different places in the manuscript, as in the fourth-century Codex Vaticanus, in which the books of Esther, Judith and Tobias are located after the Libri sapientales, away from the other books of the Ancient Historians. Our solution is to allow users to bypass the ensemble level and work with content zones only, since they offer a greater degree of precision than the ensembles yet still do not require that every book be checked.

Thirdly, as already mentioned, there are parts of the canon which differ significantly from one tradition to the next. As we still want to give users the option to represent the books according to their tradition, if the ensembles (or even zones) are used with all the items underneath, items that do not belong to that tradition will be inserted in the content description, and will need to be removed manually (before or after they are moved to the Skeleton area on the right). This is an additional step and increases the risk of errors.

This is why, as illustrated in Table 2 with the zone of Esdras,[20] specific content zones for cultural traditions or recurring special situations can be created. As for the book names, however, their internal name is identical, and they will match each other in a comparison at the zone level. The table also illustrates that the same book can be displayed with different names, for example as "A Esdras", or "Esdras III": here again, they have the same value internally, and they will be treated and displayed as equivalent items in a comparison.

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[18] See Joosten, 2017, 55–66; Williams, 2013, 527–535.
[19] For I-II Samuel + I-II Kings = I-IV Reigns, see the appendix. See Bogaert, 2014, 335–352, especially 335-339.
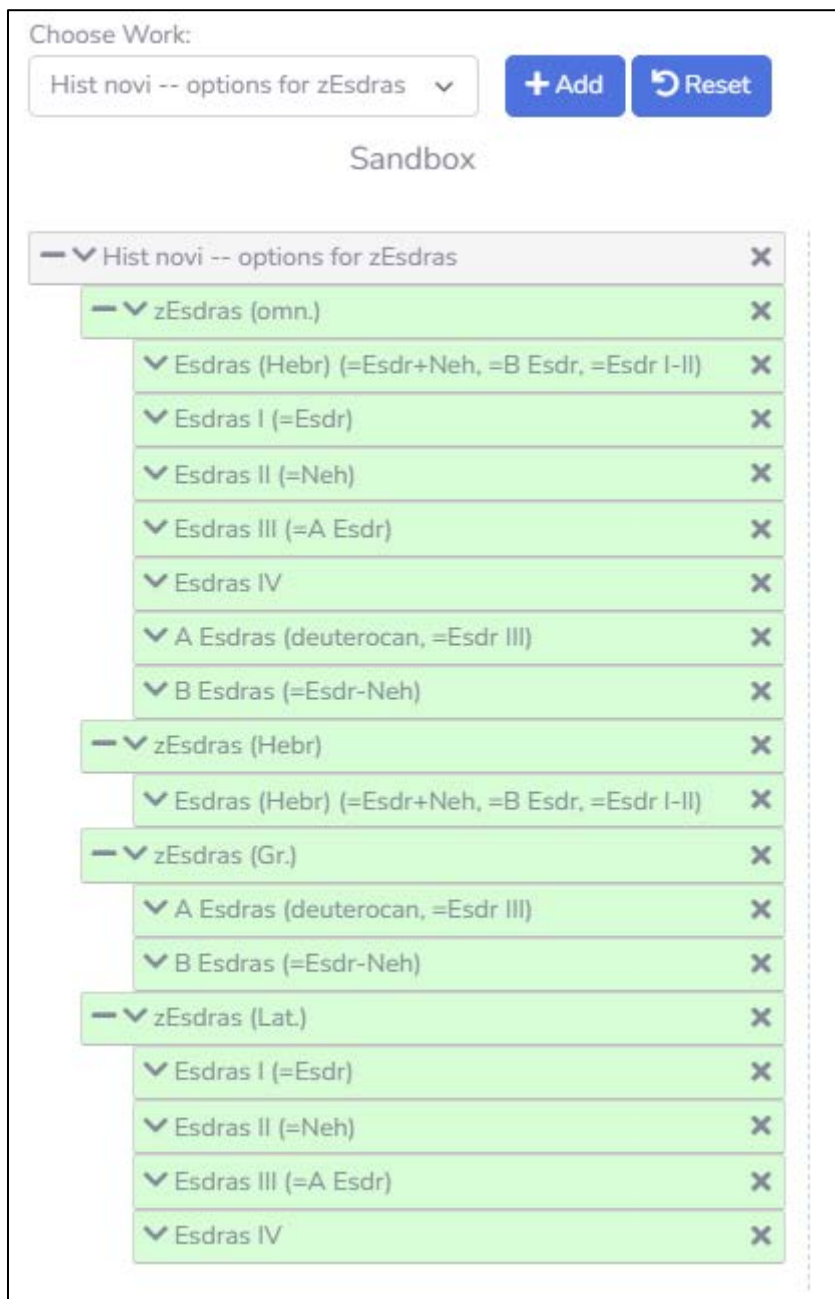[20] For an explanation about the books of Esdras, see above.

Table 2: four possible content zones for the books of Esdras: a first zone with all the books, then specific zones for the Hebrew, Greek and Latin traditions. In spite of the different zone names, the same values are used internally for comparison.

2.3 A three-level hierarchy

The result is a backbone consisting of the following three-level-hierarchy organization of the biblical content description. On the user side, none of these are mandatory:

- traditional ensembles: this level presents both "blue" ensembles, which cannot be used to create description entries with sub-items (if any), as explained above, and green ensembles,

whose attached zones and their biblical books are also created if used as description entries.[21] Users may, however, choose to describe the content at the level of the zones and not use any ensemble names. We would even recommend avoiding using them if the books which make up the ensembles are scattered throughout a manuscript;

- content zones: as explained above, for the Old Testament this is the best level for both quickly describing the manuscript and making effective comparisons. If necessary, they can be repeated in a description; in this case it is the responsibility of the user to make sure that the book names do not appear several times. A user may, however, choose not to use content zones because they are foreign to their usual descriptions. In this case, however, if a comparison needs to be made at this level, they will be automatically generated as a pre-processing operation;

- biblical books: with the same extension but not necessarily the same name as in the manuscript, as explained above. When a user decides to work at the ensemble or zone levels, no biblical books are created.

These examples show how this tool can help users quickly describe the biblical skeleton of the manuscripts.

III CHALLENGE 3: WORKING WITH INCOMPLETE OR WRONGLY REASSEMBLED MANUSCRIPTS

In most descriptions, the describer's aim is to reflect the present state of the manuscript. There are, however, situations where the current content and content order of the manuscript do not reflect the ancient state(s) of the codex. This includes mainly the following cases:

- 1: the original content is still complete in the codex today, but not in its original order, for example, if a series of quires containing several books were misplaced during a rebinding. In many cases, it only affects a limited section of the codex or biblical books whose original location is not ambiguous;

- 2: small parts of the original manuscript are now missing; this happens frequently at the beginning or the end of codices;

- 3: a large part of the codex is missing because it is now lost, or because some (or all) of the missing parts are now in one or several other repositories;

- 4: the manuscript shows several historical strata, for example, if it was restored or restructured extensively in the past. In this case, the two challenges are, firstly, to correctly reconstruct the original codex (as it was before the restorations), and then the several phases in which it evolved.

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[21] Some of the ensemble items are sub-ensembles of the ensembles considered too large to have sub-items; for example, the ensemble Prophetae maiores, to which the zone zIeremias is attached, is a sub-ensemble of Libri prophetici, which is represented in the tool as a "blue" ensemble without sub-items and is placed just before XII Prophetae et Prophetae maiores.

It often happens that several of these disturbances are found in a codex at the same time. For example, the original codex Vaticanus B of the Bible was mutilated long ago at the beginning and the end. It also lost a quire in the middle. While the content of the beginning and the middle parts do not raise any doubts, this is not the case for the part at the end, because the fourth-century copy ends partway through the Letter to the Hebrews. The Pastoral Epistles, which must have been there at one time, are lost and there is an on-going discussion among scholars whether the Book of Revelation and perhaps other books were to be found at the end. The problem, however, is further complicated by the fact that the fifteenth-century restorers, who intervened in these three places, did not see that the Pastoral Epistles were missing and only added the end of Hebrews and the Book of Revelation. As a result, one should be able to work with several states of the codex:

- a zero reconstruction of the original codex, taking only the preserved books into account;

- a conservative reconstruction of the original codex, including the Pastoral Letters, but nothing else;

- one or several more prospective reconstructions, including the Book of Revelation and possibly other books;

- and, if one wishes, the current state of the codex, without the Pastoral Letters but with the Book of Revelation, since these were the contents of the codex from the fifteenth to the nineteenth century when it was dismounted.

In the current state of our prototype, the above-mentioned case 1. is already taken into account, since users can already differentiate between the "manuscript order" (the sequence of the content as it appears in the manuscript, even if it is absurd because of misplacements of folios) and the "reading order" of the content (the sequence of the folios for the content to be read correctly, = the order in which the folios were originally copied). When making a comparison, the user will be able to decide between these orders.

The other situations can be dealt with in two ways. As our description platform does not oblige the user to link a description to an existing shelfmark, it would be quick and easy to add as many new descriptions as there are reconstruction hypotheses. This would work well as long as users do not have any other ambition than describing the biblical backbone of the codex. But if they wish to complete the description with other information, be it the folio numbers or the presence of paratexts, they would mostly need to repeat the same information in every description: this is of course very unsatisfactory. Our plan for our future Virtual Resarch Environment (VRE) is to eventually develop another tool which allows users to describe a reconstructed manuscript by reusing parts of already described manuscripts, either real or reconstructed. As a result, the user would only need to refine or modify the data concerning the peculiarities of the reconstructed manuscript.

IV CHALLENGE 4: INTEGRATING THE HIERARCHICAL SKELETON INTO THE DETAILED LINEAR DESCRIPTION OF THE CONTENT

In the framework of the current project, the descriptions of the biblical content of manuscripts using this tool are not meant to be separated from the more granular description of all the contents of those manuscripts, including the non-biblical content (mainly paracontents such as prologues, painting and so forth). The description of these extra contents is not easy to integrate in the hierarchical structure, and after a few experiments we decided to present the full description of the content in a flat representation. As Table 3 shows, the ensemble item "*Tetraevangelia*" has the same alignment as the other items, but in a different color than the description of the single pieces of content. Among these, biblical items are not presented differently than the non-biblical ones. But when working with the biblical content skeleton of this codex, only the ensemble and the biblical items are displayed (see above, and Table 4).

Table 3: beginning of the description of the contents of the codex Paris gr. 83 (*tetraevangelion*) in a non-detailed view.

Table 4: biblical content skeleton of the codex Paris gr. 83 (*tetraevangelion*) in a non-detailed view.

Several challenges attend this approach:

For example, how does one integrate new biblical contents in the description when they are added to the skeleton? After some deliberation, we decided to integrate them just before the next biblical item in the full description, after all the possible intermediary non-biblical items. But we are well aware that in many cases, users will have to correct the description manually.

A more difficult situation occurs when the codex has been rebound in such a way that the current sequence of biblical books no longer matches the original one. We suppose that most people start describing the content of a codex in the sequence it appears in the manuscript (= manuscript order), then change it if they realize this is not the correct order (= reading order). Our prototype allows both to specify these two sequences and display any of them in the flat content descriptions area. But, when this happens, what should be the working order in the biblical skeleton area? From the perspective of making comparisons with other codices, the only acceptable option is the reading order. The problem arises when users modify the biblical items or their sequence in the skeleton. In this case, the description in the manuscript order should not be affected by these changes. We also attempt to make reasonable guesses as far as possible new material is concerned, as indicated above. In any case a warning is displayed, encouraging users to check the resulting full description carefully.

One may ask, how a precise description of the contents of the manuscript can be overlaid with a generic representation of it, which can be then compared with the content of manuscripts from other cultural areas.

In summary, two sets of information form the basis for every content item that enters into the hierarchical representation of a manuscript's content. One set is a series of specific pieces of information about the content, including a specific name for the content, its language, possibly the author of the translation, the philological family to which it belongs and so forth. The other simply points to an item with a generic name for it. Let us look at an example: in a description of a Greek Old Testament manuscript, the specific information for the book of Daniel might say that it is a witness of the hexaplaric recension of the Greek translation of Theodotion, and the last chapter is truncated starting at verse two and so forth.[22] The generic name would simply be "Daniel." Then, we gather all the other generic biblical book names (and potentially any generic name of any content from the same manuscripts), as well as all hierarchically higher zones and ensembles names (and potentially other levels) defined for this manuscript. The hierarchy between those items is defined as a series of links between them. Furthermore, since any other manuscript in the database containing the book of Daniel will have exactly the same generic name in the corresponding item and will also be defined in relation to the other biblical content and hierarchical descriptors of this manuscript, it is not difficult to compare the manuscripts with one another.

Conclusion

We have shown in the descriptions above how versatile this tool, which operates at different levels, can be for working with traditional ensembles and how it can allow users to create new biblical contents very efficiently. By creating technical "zones" as an intermediary descriptive level between traditional ensembles and single books, it helps one avoid the pitfall of limiting description and comparison possibilities either to a level of specificity and granularity where all the books are included with precision or remaining at the very superficial (and often insufficiently) telling level of the traditional ensembles.

When users want to use the tool to make comparisons, they not only need to select the descriptions to be compared, but they also must designate at which level and for which part of

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[22] Ziegler Munnich Fraenkel, 1999, 9–161. See also Settembrini, 2019, 585–597, especially 587–588.

the Bible the comparison should be made. For example, they can decide to compare the contents of the historical and prophetical books in three manuscripts at the zone level and they might find out that, in spite of differences at the single-book level, the three manuscripts are indeed quite similar. How the result of this comparisons can be presented most effectively is still an open question. We are looking for a solution where all the items of the compared manuscripts are mentioned in the original order, highlighting the common sequences and repeating items with a special presentation if necessary.[23] There are no immediate reasons why there should not be several possibilities for presenting the result of the comparison, including some more graphic representations.

As explained above, the scope of our prototype is limited to the biblical content of biblical manuscripts. But if we can keep developing the tool, there is no reasons why other frequent contents of biblical manuscripts such as *kephalaia* or the Eusebian Canons could not also be included in an expanded hierarchy of four or more levels. On an even broader scale, this technology, which we apply here to biblical books and their ensembles, could also help describe and analyse other types of manuscripts whose main content is made of smaller pieces which follow (somewhat) established patterns of textual arrangement, such as collection of fables, apophthegms, sermons and so forth.

As will be clear to the reader by now, there is still some way to go from this prototype, which concentrates on basic functions and on solving essential problems, to a user-friendly tool. But we look forward to receiving useful feedback from readers which will assist in the improvement of our tool, which we see as one of the first steps toward the development of a powerful VRE for the study of manuscripts. Presently, we hope that the project will secure the necessary funding that will allow us to keep on this promising path.

AUTHORS' CONTRIBUTIONS

Patrick Andrist is responsible for the seminal ideas about the tool and its theoretical framework. Together with Tobias Englmeier he designed its internal functioning and conceived the underlying database structure. He coordinated/led the team.

Tobias Englmeier realized the Prototype. Together with Patrick Andrist he designed its internal functioning and conceived the underlying database structure. He contributed several important functional and practical ideas.

Saskia Dirkse tested the tool from the beginning and contributed many ideas about the functionalities, the display, and the redaction of this article, which she proofread.

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[23] For a manually prepared example, see Andrist, 2020, 72.

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APPENDIX

List of the Christian biblical books grouped into zones.

The Old Testament follows the order in the Rahlfs edition.[24]

The New Testament follows the order of the Nestle Aland 28th edition, 2012.[25]

Old Testament (notes)

zPentateuchus			Samuelis I	I Sam	
Genesis	Gen		Samuelis II	II Sam	
Exodus	Ex		Regum I	III Regn	
Leviticus	Lev		Regum II	IV Regn	
Numeri	Num		Regnorum I	I Regn	= I Sam
Deuteronomium	Deut		Regnorum II	II Regn	= II Sam
zIosue-Iudices-Ruth			Regnorum III	III Regn	= I Regum
Iosue	Ios		Regnorum IV	IV Regn	= II Regum
Iudicum	Iud		zChronicorum		
Ruth	Ruth		Chronicorum I	I Chron	
zSamuelis-Regum					

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[24] Rahlfs Hanhart, 2006. However, the Psalmi Salomonis are classified in the Other Books.
[25] Aland Aland Karavidopoulos Martini Mezger, 2012.

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Chronicorum II	II Chron	
Paralipomenon I	I Par	= I Chron
Paralipomenon II	II Par	= II Chron
zEsdras		
Esdras-Nehemias	Esdr-Neh	In one book
A Esdras	A Esdr	
B Esdras	B Esdr	(=Esdr-Neh)
Esdras I	I Esdr	= Esdras
Esdras II	II Esdr	= Neh
Esdras III	III Esdr	= B Esdr
Esdras IV	IV Esdr	
zEsther-Iudith-Tobias		
Esther	Esth	
Iudith	Idth	
Tobias	Tob	
zMachabaeorum		
Machabaeorum I	I Mac	
Machabaeorum II	II Mac	
Machabaeorum III	III Mac	
Machabaeorum IV	IV Mac	
zPsalmi		
Psalmi	Ps	
Odae	Od	
zSalomonis		
Proverbia	Prov	
Ecclesiastes	Eccle	
Canticum	Cant	
zIob		
Iob	Iob	
zSapientia-Siracides		
Sapientia	Sap	

Siracides / Ecclesiasticus	Sir
zXII-Prophetae	
Osee	Os
Amos	Am
Michaeas	Mich
Ioel	Ioel
Abdias	Abd
Ionas	Ion
Nahum	Nah
Habacuc	Hab
Sophonias	Soph
Aggaeus	Agg
Zacharias	Zach
Malachias	Mal
zIsaias	
Isaias	Is
zIeremias	
Ieremias	Ier
Baruch	Bar
Lamentationes seu Threni	Lam
Epistula Ieremiae	Ep Ier
zEzechiel	
Ezechiel	Ez
zDaniel	
Susanna	Sus
Daniel	Dan
Bel Et Draco	Bel
Oratio Manassae	Or Man

New Testament

zEvangelia	
Matthaeus	Matth
Marcus	Marc
Lucas	Luc
Iohannes	Ioh
zActus	
Actus Apostolorum	Act
zPaulus	

Ad Romanos	Rom
Ad Corinthios I	I Cor
Ad Corinthios II	II Cor
Ad Galatas	Gal
Ad Ephesios	Eph
Ad Philippenses	Phil
Ad Colossenses	Col
Ad Thessalonicenses I	I Thes

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Ad Thessalonicenses II	II Thes	Petri I	I Petr
Ad Timotheum I	I Tim	Petri II	II Petr
Ad Timotheum II	II Tim	Iohannis I	I Ioh
Ad Titum	Tit	Iohannis II	II Ioh
Ad Philemonem	Philem	Iohannis III	III Ioh
Ad Hebraeos	Hebr	Iudae	Iudae
zCatholicae		zApocalypsis	
Iacobi	Iac	Apocalypsis	Apoc

(Other books)

zAliiLibri

Barnabae	Barn
Clementis ad Corinthios I	I Clem
Clementis ad Corinthios II	II Clem
Pastor Hermae	Herm
Didache	Did
Psalmi Salomonis	Ps Sal