"Introducing the Structural Visualization of Manuscripts (StruViMan): Principles, Methods, Aims and Prospects."

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In this paper, we would like to introduce a tool which offers a new way for scholars to visualize the structure of medieval manuscripts. The Structural Visualization of Medieval Manuscripts (for short, StruViMan) came into being in the frame of an ERC proof of concept project, as a practical extension of ParaTexBib, an ERC project based in Munich and led by Martin Wallraff and Patrick Andrist. Today's demonstration marks the first time that the StruViMan tool is shown outside of our immediate institutional setting. We're excited to be sharing it with you and would like to underline that this prototype represents a work in progress. As we continue to work to its completion, its functions and features wil become more fine-tuned and sophisticated.

The ParaTexBib or Paratexts of the Greek Bible project has as its central aim to present a comprehensive survey of the paratextual material in manuscripts of the Greek Gospels from the 2nd to the 16th centuries. On the basis of digital reproductions (such as those made available through the New Testament Virtual Manuscript Room in Münster), each manuscript is carefully reviewed and the presence of biblical texts and paratexts is documented within the framework of the Pinakes database.

The ParaTexBib project's approach to manuscript description is built on the methodologies set out in the *Syntaxe du Codex*, which appeared in 2013. The authors of this work view the medieval manuscript as a complex, dynamic and layered object whose intricacies of composition and structure require a methodological approach that is both comprehensive as well as finely articulated. Another important feature of the *Syntaxe du Codex* is the emphasis on a clear distinction between the codicological and the textual features of the medieval codex and the need for a descriptive framework which can navigate and disentangle the often complicated diachronic interplay between them. It is with this idea of the codex as an object evolving over time that StruViMan was conceived as a way translate the different stages in a manuscript's development into a visual model, based on the physical historical layers of the codex (its stratigraphy, if you will).

In order to understand how the StruViMan tool takes manuscript data and transforms them into a visual representation, it is perhaps instructive first to examine some of the organizing principles of manuscript description as practiced in the PTB project. Let us take as our example the Codex Bodmer 115, which is a collection of treatises on military science. In the PTB project, our focus is almost exclusively on biblical manuscripts but in order to show the wide applicability of the tool to manuscripts of all kinds, I have opted to begin with a non-biblical codex. The description in Pinakes is organized in such a way that it allows the reader to approach the codex both "vertically" (to borrow at term from J. P. Gumbert), meaning that one can see at a glance the different stages of development over time, and also "horizontally, in the writing ([or] the reading order)" what pieces of content appear where in the manuscript.[1]

For the vertical approach, each individual stage of the manuscript's manufacture is represented by a separate production unit (in Pinakes, a codicological unit) which has been defined by the authors of the *Syntaxe du Codex* as "the part or parts of the codex which are the result of one and the same act of production." Production units depend heavily on the quire structure of the codex but also define an intermediate historical structure between the quire and the complete codex.

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[1] Patrick Andrist, Paul Canart, and Marilena Maniaci, *La Syntaxe Du Codex: Essai de Codicologie Structurale*, (Turnhout, Brepols, 2013), 25.

We see that for the Codex Bodmer 115 there are four discrete production units: the first three (1-3) are all the work of the same scribe, Camillo Zanetti, but their time of production can be situated at different points in the second half of the 16th century with reasonable certitude. The last production unit (4) is dated to the second half of the 18th century. From a horizontal perspective, we see that there are three different large pieces of content, organized by author or category and by work (*œuvre*), this being the classification standard in the Pinakes database. These are a paraphrase of the emperor Maurice's *Strategicon*, the *Velitatio Bellica* by Nicephorus Phocas and Book 7 of the *Cesti* by Julius Africanus. The three pieces of content are spread over four production units, since Book 7 of the *Cesti* was written in two stages: the first part was copied by Zanetti (this is the third production unit), while more content was added during the latter half of the 18th century (this is the fourth production unit).

Now that we have briefly gone through the structure of the description in Pinakes, let's see how the StruViMan tool is able to generate a visual model from these data. A very brief word about tool's technical specs: StruViMan is a web application built using JavaScript and other common web technologies such as HTML5 and CSS3. Our programmers built it entirely using a Javascript web framework called Vue. When it goes live, the StruViMan tool will be made available to the public through a web service installed on a server of the Ludwig Maximilian University in Munich. In order to make the data communicable to the StruViMan tool, the calling program must provide Struviman with a series of XML tables for each manuscript and its different parts: one for the whole manuscript, one for each production unit and one for each content item.

Any manuscript database or software able to supply the correct XML tables according to the StruViMan's requirements will be able to use Struviman.

The process then unfolds in the following way: the calling software (in this case, Pinakes) calls the StruViMan web service and sends XML data corresponding to the manuscript which the user wishes to have displayed. It may be a single long string containing all the required XML data or an address on the web where such data may be found. As StruViMan opens, the manuscript visualization appears in a scrollable browser window and here we see the visualization for Codex Bodmer 115, the manuscript we just saw in Pinakes. Starting at the top left-hand side of the window is a bar called the Home Panel, which contains a clickable drop-down menu that lists the manuscripts that have been sent to StruViMan by the calling software; presently this is only a single manuscript. Next to it are a number of buttons which allow the user to tile all the manuscripts in the list, to show all, close all, or delete all manuscripts. d.

Moving down, we see a label containing the manuscript's identifying information; in this case the repository, the shelfmark, a title assigned to it in Pinakes, and the Diktyon number. The blue button below it allows the user to create a screenshot of the visualization which can be saved to their computer; the green button beside it lets them determine whether or not they would like the various labels to appear in the visualization (and the screenshot).

Below this, and taking up the largest part of the screen, we see the visualization meant to call to mind a book viewed from the side; here are its covers and spine on the outside and the book block is visible here on the inside. What do these different parts represent? Let's start with the outside layer: here we see that the spine consists of a bar divided into four differently-colored sections. This we call the Structure Bar; it shows how many production units are present in the manuscript and at what point in the manuscript they occur. If you recall, the Codex Bodmer 115 has four production units and they are labeled with their corresponding number and date. If you scroll to the bottom of the window, you find a table with further information about the manuscript, including any known owners and scribes, comments (if any), and a link the the Pinakes entry. Now let's have a look at the individual sections in the Structure Bar. When we click on an individual section, the information in the table below changes to give a more detailed overview of the section in question, including the folios it covers, the date, the scribe, and any comments. The information changes again if one clicks on a content item.

Another feature which you may have noticed is that when you click on any section of the Structure Bar, a bright green box appears which extends to the "book block" inside the "book." This second bar is called the Content Bar; it not only gives an overview of the pieces of content inside the book, but also show how much space each occupies. The green outline only includes the content associated with the first production unit, the emperor Maurice's *Strategicon*; the same thing occurs when you click the other sections. When we move our cursor to the Content Bar and click there, we see that the green outline encompasses only the piece of content and that the table below now changes to *Item*, which gives information about the work, including its relation to that production unit and any comments. The visualization thus allows the user easily to distinguish between a manuscript's different production units and also their relative content and size.

The Codex Bodmer 115 is a relatively straightforward manuscript in terms of its structure and content, but what happens when we feed a manuscript into StruViMan which has more production units and content of more varying sizes? The manuscript British Library, Additional 33227 is a ninth-century Gospelbook which saw the addition of a set of liturgical tables in the 13th century and a number of restorations, to compensate for the loss of parts of the Gospel of John, in the 16th century. In terms of content, it has not only the four Gospels but also a modest selection of standard biblical paratexts comprised mostly of lists of chapter titles and epigrams (these are the ones labeled by their *incipit*). When we look at the visualization, the later interventions in the codex become clearly visible: we see the liturgical tables distinct from the rest of the original production unit, and the restored folios of the Gospel of John are thrown into relief by the change in color in the Structure Bar.

One of the particular challenges we faced in establishing a workable visualization was dealing with pieces of content of such varying sizes. In this manuscript, the Gospel of Luke covers nearly a hundred folios, while the epigram and chapter list that precede it take up a mere three folios combined. In the default mode (where content is displayed proportionally, i.e. by the number of folios it occupies) brightly colored slices of the epigrams and chapters are dwarfed by the gray-toned Gospels around them. This is where the Advanced Mode alluded to earlier on offers a greater degree of customizability in the display for those users wishing to highlight or minimize particular aspects of a manuscript in a visualization. The user can switch modes by clicking on the orange button in the top right corner of the screen. You can do this in the Home Panel, which will apply all mode changes to all manuscripts, or you can change the mode to individual manuscripts by simply switching the mode in the individual manuscript window. If we now click on the button with the settings wheel, a small window appears with further options for customizing the display. So as to prevent these smaller paratexts from disappearing from view between the more sizable biblical texts, an alternate display mode is what we call logarithmic, meaning that longer texts are scaled down while the size of the paratexts is enhanced. You can opt to display or hide the labels for the Structure Bar and the Content Bar, and the segment display in the Content Bar can be changed from proportional to equal. This of course causes some loss to the sense of spatial distribution of different pieces of content, but it has the advantage of showing the sequence of pieces of content much more clearly. The CU equal display mode and the Content Segment equal in CU mode both offer further insight on how production units and content are distributed throughout the codex. Lastly, there is also the option here to have all changes applied to all open windows. In the future, more features will be offered, such as further types of proportional display and color customization.We are also planing to offer a reconstruction function, when user could bring together sections from various codices in order to show a reconstructed one. If everything goes according to plan, we hope to make it available already in the first verstion of Struviman

If we return briefly to the manuscript list in my Home Panel, you can see that currently, Bodmer 115 and Additional 33277 are the only codices available. We can, however, add up to fifteen additional manuscripts to "My Manuscript" list and get a little snippet view of each manuscript by clicking on it. Opening and tiling a great number of manuscripts at once exceeds

the capacity and width of most computer monitors, but on a regular-sized screen one can easily open up to four manuscript visualizations for side-by-side comparisons. The session in the StruViMan web tool continues as long as the browser window remains open. If a tab with a particular manuscript visualization is closed, another StruViMan tab can be opened and the manuscript will be preserved in the new tab's manuscript list. The same thing happens if you have multiple manuscripts open in a single screen: if you click an individual manuscript away, the visualization disappears but the manuscript remains on the manuscript list. Closing the browser window effectively ends the session, along with its data and settings.

At this point, I would like to conclude the demonstration with a few future prospects for the StruViMan tool.

- Still being developped… Today we've only seen the tool interact with manuscript data from the Pinakes database. But, as I said, StruViMan will be able to generate manuscript visualization for any software or database able to provide the appropriate XML tables. The XML data format should allow the tool to be useful not only to biblical material but to manuscripts of all kinds, and render it highly customizable. [? Given that StruViMan is not a website with public screens or windows but rather a web-service with a web application available to interact with any compatible program on the web, it is easily accessible by programs ??].
- Moreover, in the StruViMan functions and code will be open source and freely downloadable from our website so that developers be able be incorporat it on their platforms.
- We are planing to make Struviman accessible to the public by the end of the summer of this year.

In closing, we would like to recognize the constructive and helpful feedback that we've received from several people, including our colleagues at the Bayerische Staatsbibliothek, and we look forward to bringing the StruViMan to a wide and diverse audience of potential users as we work on bringing the project to completion.