



Computational approaches and the epistemology of scholarly editing

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Abstract

Digital Scholarly Editing has followed a fundamentally conservative model over the last forty years. As a result, the epistemological advantages of digital possibilities have not yet been fully explored. The current article proposes that alternative models for editions (e.g. graphs) provide new conceptual and practical opportunities, importantly moving scholarly editing from a static result-oriented practice towards a dynamic knowledge process oriented one. By means of a concrete example, which uses the glyph as its key building block, we suggest that part of the reasoning in the constitution of digital scholarly editions will shift from implicit in the scholar to explicit in forms of code and explicit analysis, calculation, reasoning and logic, and that this will necessarily have significant implications for the nature of authority, the requirement for transparency, the operationalisation of workflow and, ultimately, the very nature and conceptualising of the works that we study.

Keywords Computational philology · Text as a graph · Scholarly editing · Modelling philological process · Epistemological turn · Operationalisation

1 Introduction

It has often been noted that the revolution in digital scholarly editing has not yet happened (e.g. Bordalejo, 2018; Robinson, 2016; Roelli, 2020; Van Zundert, 2019) - one might be tempted to ask the question if it ever truly will. In what follows, we attempt to address some of the reasons why the extensive advances (Stella, 2018; Institut für Dokumentologie und Editorik, 2022; Boot et al., 2017; Roelli, 2020) which have been made in the field have, for some at least (Van Zundert, 2016, p. 105–106; Andrews TL, 2013, p. 66), left a lingering sense of opportunities missed and of disappointment that the potential for epistemological change in the very exercise of scholarly editing - perhaps in a way that could generate widespread re-evaluation of

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the very underpinnings of humanities research and practice - has not yet materialised. Although there have been many notable recent efforts to point to the importance and relevance of philological methods (McGann, 2013; Pollock, 2009; Bod, 2015), it remains the case that philology is still often seen as a conservative discipline with the auxiliary role of “producing” authoritative texts for other disciplines (McGann, 2013). We argue that a positive engagement with the implications of technological advance, allied to the forward-thinking reconceptualising of philological principles alluded to here, rather than a grudging acceptance for the need for change (Brennan, 2017; Kirsch, 2014) that is often the brush with which humanities researchers are tarred, will mean that (digital) scholarly editing can be at the forefront of an epistemic reappraisal of humanities disciplines.

Over the next 30 years, it is likely that the combined effects of increased computing literacy, developments in artificial intelligence (AI), and the inevitable data deluge whose initial waves we have been and are currently experiencing (Berry & Fagerjord, 2017; Karjus, 2023; Crane, 2006), will provoke a fundamental shift in philology and textual editing - from their current status as a scholarly informed craft to a formalised modelling exercise using computational techniques. We contend here, however, that this process of editing, which will be the contingent establishment of data archives and a concomitant and equally contingent compilation of assertions about a work (Andrews, 2023), will continue to be inflected and informed by the kinds of scholarly knowledge and understanding that have always formed the backdrop to scholarly editing (Eggert, 2009, 2019). Far from erasing the polyphonic vagueness of humanities knowledge, truly digital editing will not only permit such polyphony but will have it as a central principle, using it as a means for constructive “irritation”. In return, the ever-increasing volume of data will require algorithmic reasoning to convert data to understanding and to reveal the relative validity of competing assertions. We argue that inevitable technological advances will provide previously unsuspected advances in humanities scholarship, but that these will also require a profound reflection on the very nature of the object of study and the transparent authority mechanisms which will be required in the critical editions of the future.

Implicit reasoning and reputable authority, which still characterise (digital) scholarly editing (Dahlström, 2008, p. 37-38), urgently need to be replaced by explicitness, not only at the level of results, but also at that of processes, and with respect to the formality of reasoning. Such paradigmatic change in methodology is, in our opinion, the necessary condition for our editions to be in line with scientific standards and therefore for them to be considered of authoritative value, thereby generating trust. Nowadays, it is uncontroversial to state that a scholarly edition is to be considered as a “working hypothesis”, rather than a “rigidly determined reality” (Puppo, 1968)¹.

This is closely related to a more profound condition of Humanities research, which depends on the ontological status and situatedness of its research objects and the strongly interpretative nature of the methods required to study them (Fickers, 2020; Borgman, 2015). Having accepted this intrinsic truth, the constraints of theoretical rea-

¹ [O]ggi il testo critico appare non tanto una realtà rigidamente determinata, quanto un'ipotesi di lavoro, variabile a seconda delle singole situazioni concrete.” (“Today, the critical text appears not so much as a rigidly determined reality, but rather as a working hypothesis, subject to variation depending on the individual concrete situations” [our translation].)

soning oblige us to play with open cards. Of course, we are not the first to acknowledge this: philologists have always been very accurate in describing their editorial criteria and in providing very detailed critical apparatuses (cf. e.g. Macé et al., 2020; Heinze 2003). This is indeed part of the established methodology in the field of scholarly editing, both in traditional paper editions and in digital ones. However, we would like to argue that discursively explaining the editorial principles in an introduction and presenting the data one had at one's disposal while creating the edition is not in itself enough. While state-of-the-art digital editions are already exploring and exploiting the potential of borderless digital space to provide the user with a high quantity of annotated and structured data, there is still a fundamental part of the editorial workflow which remains hidden; namely the case of the actual editorial processes which produced the data in the first place. We are referring here to scholarly arguments, the reasoning at the basis of the editor's decisions and the very actions taken to produce the edition. We believe that, every bit as much as data, arguments which lead to the establishment and selection of these very data are part of the evidence we, as Humanities scholars, should open up to our audience. In particular, we envision a possibility of publishing such arguments in a formalised logical form, which can be operationalised, evaluated, and, where required, falsified. These arguments would also make the provenance of the (semantically annotated) data explicit, thereby reaching an unprecedented level of transparency.

The baseline question that we address here then, is if, and to what extent, any of the revised approaches to textual criticism and scholarly editing truly constitute the kind of fundamental, epistemological, difference in the theory and practice of (digital) scholarly editing that Eggert (2009) alludes to. Our contention here is that it is indeed the case that the digital editions of the future will be epistemologically distinct from those that we have produced in print and in hybrid digital form to date, and that there will be a concomitant alteration in the conception of the object of humanities research more broadly. We suggest that one way to show this is through a simple litmus test: "how do we know what we know? And is the answer incontrovertibly different to the same question posed for print editions?". Our hypothesis is that the answer for future editions will be "yes", for a number of reasons. First, the constitution of digital scholarly editions will mean that part of the reasoning will shift further from implicit in the scholar to explicit in forms of code and explicit analysis, calculation, reasoning, and logic; however, this will not mean a reduction in the ambiguity and fluidity of human reasoning, merely that the fundamentals of that ambiguity will be shifted elsewhere in the process. Second, the nature of "auctoritas" - the place where truth is established - will also shift, and with it there will be an alteration in the notion of trust. The algorithmic reasoning carried out by computing processes will require the establishment of clear processes of trust, authority, and responsibility. Third, the cultural patterns of creating digital editions, understood as a range of positive assertions about a defined body of data, and the downstream modes of sharing interpretation and knowledge about an object of study, will have to be identified and made explicit. Fourth, the analytical and epistemological potential of formalising and operationalising the editorial workflow and its inherent complexities will imply a fundamental shift in how we understand the works we study. Fifth, the possibility of embedding different forms and classes of knowledge (e.g. prosopographical knowledge, geospatial information,

syntactic information, direct links to source and reception texts) in the future digital edition will give rise to the production of different kinds of understanding. Graph-based editions will allow for reading as path traversal in multiple dimensions and directions, and perhaps mimic cognitive processes as a result. Editions will therefore become contingent containers of the knowledge and understanding about a work, expressed as a series of assertions.

In order to address these epistemological questions by reference to a concrete example, our contribution is structured as follows: in section two, we will raise some fundamental theoretical aspects which, as we will show, determine a veritable epistemological turn in the field of scholarly editing. We will claim, as a matter of fact, that while the scalability of the digital space has determined a rise in the quantity of knowledge we can include in our editions, it is still not enough to justify a paradigmatic change in the way we acquire our knowledge and in the type of findings we can infer from it. In section three we will underline some problems of state-of-the-art digital editing, taking into consideration advantages and disadvantages of the standards used in the field. In particular, we will reflect on the operationalisation of the process of interpretation in digital scholarly editing and in adjacent fields. Section four will present the core of our proposal, showing what role computation can and should play in the editorial workflow and maintaining that it is only through a specialised formal logic that we can express the reasoning at the basis of our editorial decisions. We will deal with the concepts of provenance and semantics in an attempt to formalise and operationalise the scholarly work at the core of the editorial praxis. Section five, finally, will present a possible application of the methodology we propose, emerging from a case study from one of our projects.

2 A possible epistemological shift

Our analysis here addresses very general epistemological and phenomenological questions about digital and noumenal objects (and one might object to the ascription of noumenal to those objects which are the focus of our research in the first instance); but the examples that we are using are very specifically related to heritage objects, and this already presupposes a range of questions of a historical order. Furthermore, since the focus of our work is on critical editing, and very specifically on textual heritage objects of a very particular, manuscript kind, there is an obvious question to be asked about the extrapolation of general principles, and thus epistemic bases, from these very specific phenomena. This is always the case, of course, and it leads us to posit two possible approaches to the question of analysing whether there is truly scope for epistemic change in textual editing, top down and bottom up, in the understanding that our answer might be a combination of both.

A possible way into effecting epistemic change is by considering that the conceptual frame or architecture of the digital world is substantively different to that of the pre-21st century world and it is our task to tease out the possibilities, and limitations of this conceptual architecture such that we arrive at a revised notion of the object of (humanities and social science) research. One way to approach this question is to assume not a society in which everything is representable by data, but rather one in

which everything is data - recurring patterns of 1s and 0s (cf. Heßbrüggen-Walter, 2020). In this case, the epistemological question becomes an ethical one - on what basis and with what authority can any of the *primaeval* digital soup be corralled off, in however contingent a fashion, to form something which could be regarded as an appropriate object of (humanities and social sciences) study and its attendant contextual elements? Such an approach in its purest form presupposes beginning the process of conceiving the very notion of textual edition from scratch; something which seems to us to be, if not impossible, certainly unlikely and disadvantageous. But the notion of contingent, but contextually and ethically defined, assertions about data which has been circumscribed for an explicit purpose, has much to recommend it, without the need to scrap all previous forms of knowledge.

The alternative approach, which might be regarded as a conservative option, is to examine the epistemological bases of critical textual editing as they have evolved through usage up to this point, and to seek to modify, adapt or revolutionise these in respect of what is now becoming possible. The central questions here might be an examination of the extent to which our (textual) cultural understanding is a function of the physical limitations of the forms in which we have accessed it, and in parallel, the extent to which this cultural understanding has been naturalised by the congealed forms and conceptualisations which are in fact the product of historically contingent phenomena. Here the *mediaeval* manuscript might help us to revise our understanding of the ways in which print encoded meaning, and by extension created a particular object of study in critical editing (cf. Sahle, 2013a; Armstrong, 2016, 34-35). Print may well have allowed for an expansive understanding through mental prompts, but the technology of reproduction prompted similar reading and may have fixed a range of meanings in an authoritative manner. A history of editing which is also the history of the eradication of 'error' and the backwards search for meaning, is not one which is appropriate for a digital disposition of fluid and relational meaning necessarily placed in a global context.

If we were to ask what categories of thought and what bodies of knowledge are provided for by a *mediaeval* manuscript, a printed book and a digital critical edition, we might then be in a position to propose a relational model of editing which accounts for all of them in appropriately fluid fashion. Whereas the focus of a print edition regularly was the text of a work, understood as a fixed ideal form (however contingent on the state of knowledge about it) the focus of the digital edition would be the document and the creative linkage of data, knowledge, about it. Some of that knowledge can be proximate and other relatively distant, and it can be different classes of knowledge (ranging from, for example, variant documents, geolocation data, source materials, syntactic analysis, content analysis) arranged in ever changing matrices of knowledge. The object of study then becomes potentially infinite, rather like the mental images of the reader, and is defined by the edition as the contingent container of a permanent unfolding dialectic (Eggert, 2009); one which justifies its existence and authority (and thus choice of data) as an ethical stance on (the) data as a whole (cf. Sahle, 2013b). In this disposition, the two approaches outlined here meet. If we propose that an epistemic leap in the very essence of textual editing is possible, not because of the volume of data or variety of classes of data that an edition can encompass, but rather because of the ways in which the totality of the data and assertions about it are conceived, it is

then incumbent upon us to suggest how that might be achieved in a radically revised model of process.

3 From models-of-text to models-of-process

In the previous section we argued that the epistemological gambit of the digital environment for textual scholarship is in the ways in which the totality of the data and assertions about it are conceived. It follows that any fruit of this gambit must be sought in a digital or computational praxis for textual scholarship that does not limit itself to some expression of “the data” or “the text”, but that encompasses the assertions that have been made about that data and, moreover, the processes that led to these assertions. The “totality” of the textual scholarly process is its data and its rules of editing. It is the text *and* the processes of interpretation that inform its scholarly criticism. This section deals with the question of whether current digital and computational models applied in textual scholarship actually facilitate this complementary view of textual scholarship practice in which both data and process of interpretation are represented. Our conclusion is that they do not. This leads us to contend that to realise any of the epistemological potential alluded to, we must radically make the scholarly process of interpretation the intent and the object of any digital or computational modelling in textual scholarship.

The scholarly community in the last two decades has produced a multitude of text models that are alternatives to the standard of TEI-XML (Bleeker et al., 2021; Neill & Kuczera, 2019). The fact that scholars and research software engineers feel the need to model and re-model what text is, can be taken as an indication that the prevailing standard of TEI-XML, based on a hierarchical structural view of text (DeRose et al., 1990) does not meet all needs of the philological community. Some scholars have theorized why this might be. Buzzetti (2002), for example, argues the inadequacy of hierarchical models to capture the fundamentally non-hierarchical aspects of text. Sahle (2010) reflects on the limitations of XML also, especially from a medial point of view: while he argues for the necessity of a transmedialised annotation practice, at the same time he recognises the impossibility of overcoming the physicality of the medium. Van Zundert and Andrews (2017) argue the inadequacy of current models to comprehend digital forms of texts and documents, Neill and Kuczera (2019) address the inability of current models effectively to treat provenance and subjectivity. Essentially this contingent of the discourse argues that the models in existence are inadequate for expressing properties of texts that these scholars think are essential to explain or understand text. Others propose a stand-off markup alternative, TAG-ML, that enables multi-layered annotation, which fulfils the intention to express multi-perspectivity of interpretation (Bleeker et al., 2021; Haentjens Dekker & Birnbaum, 2017).

We argue that there is a common underlying problem that “informs” these criticisms that we also observe in adjacent fields: the inability of current textual models to formalise the actual interpretation processes at the basis of textual scholarship. Pichler and Reiter (2022) reflect on the relationship between theory, processes (or methods) and data, the latter both as input or starting point of a scholarly analysis and as result of it. Their definition of theory is procedural, as they accept, at least partly, Bridgman’s

equation according to which a “concept is synonymous with the corresponding set of operations” (Bridgman, 1927, p. 5). They derive the conclusion that the scholarly methodology should be operationalised: as a matter of fact, the scholars consider it as the development of a detection procedure meant to bridge the gap between theoretical concepts, which have the role of predicting and explaining, and their instantiations (observed phenomena). In particular, the latter should be found, measured and processed in an unambiguous way, in order to create a clear relation between theory and data (or “facts”). Pichler and Reiter essentially demonstrate that to define a “metre” is to define unequivocally the operations that allow us to state what a “metre” is.

Meister (2022) argues for a departure from traditional philological practices, advocating for a born-digital modelling of text annotation that can adapt in real-time to methodically connected computational processes. He underscores the significance of a comprehensive integration of text markup, annotation and analysis, envisioning a seamless workflow that mirrors discourse-driven practices in literary studies. Bode (2023) criticises the dichotomy that emerges from the field of literary studies: scholars working with traditional methods often reduce interpretation to a fully human activity based on mere “reading”, while digital scholarship tends to be identified as an empirical, quantitative approach based on statistics also by those scholars who have indeed embraced digital methods. Bode observes that the tendency of the debate is to state that “where the machine is, the human is not, and vice versa” (p. 522). She argues that we need improved methods for humans and machines to collaborate effectively in synergy, which means turning reductive interpretation processes into “augmented”, more powerful ones. To do so, we add, it is necessary for textual scholarship to focus on expressing process, rather than mere results. This is clearly in line with other scholars’ reflections on the textual condition (Buzzetti & McGann, 2006), who stress that “interpretation” is actually always also ever-changing, ideo-hermeneutic “re-interpretation”.

Upon this realisation, Vogeler (2021) proposes a shift in perspective, advocating for the embrace of multiple models. His argument centres on the idea that specific models serve distinct purposes, and the objective should be to identify the optimal combination among them. Vogeler contends that each model emphasises different facets and properties, acknowledging that none are flawless. Nevertheless, each model provides unique insights into understanding and working with texts. The diversity in models becomes an asset, offering richness in exploring various approaches. However, a potential challenge arises when these models become mutually exclusive, operating with incommensurate semantics. Vogeler suggests that while letting a thousand flowers bloom is encouraged, the key lies in finding the transformative “glue” that facilitates communication between these models. However, we would like to warn against an approach that retains models along with their inherent problems, without providing genuine solutions.

The textual realm we, as philologists, explore involves inscriptions on stone, glyphs in manuscripts, or text on a papyrus roll. We assert that philology has thus far overlooked the critical step of precisely articulating the process of interpreting such material traces. Existing models establish a tagging semantics based on community agreement, neglecting the preceding interpretation process, revealing themselves therefore to be epistemologically “lossy”. We mean lossy here in the sense in which it is used in

the technical context of compression algorithms which are not guaranteed to preserve “all” information, but more or less only the essential information. In essence, this is also what happens, with current digitisation technology in any event, when we recode any document carrying text into a first representation in a digital text format and when the latter is used as the basis of the creation of any (digital) scholarly edition. This representation, even with Handwritten Text Recognition (HTR), is a rather crude reduction of the original document, which loses all material information and particulars of codicology, and transforms all idiosyncratic details of the artefact to a mere linear representation of uniform digital characters. A system of annotation (such as TEI-XML) is then put in place to amend and interpret the text for observations made from the original document. We contend, however, that during the process of digital scholarly editing, much of the digital surrogate is reified as the “actual text”, also by the textual scholar. Because of methodological choices, like taking the character stream as the starting point for the interpretative effort, the critical mass of interpretation is necessarily driven by that digital character stream itself. While intensely working with a technology that supports your task, the technology also starts to a certain extent to determine your interpretation. If it is the digital text stream that is in focus most of the time, the material artefact is not.

Furthermore, in practical terms, tagging is confined to a single domain. Attempts to tag multiple domains (e.g., paleographic dimensions and poetic structure or syntactic elements) lead to semantic clashes and conflicts. Sahle tackles this theoretically by embracing complexity in a text model that recognizes multiple text representations, one for each expressive domain. We argue that by tagging texts from these more extensive agreed-upon structures, collisions are inevitable as they inherently involve mutual exclusivity. Furthermore, it is not always wise to study text by subdividing it into different compartments, as it is often the interplay of the latter which determines the very essence of text. To resolve this, we propose increasing the granularity of tagging so that super-structures can be constructed from sub-structures. Operationalising these interpretation processes, we believe, can eliminate most challenges that various models attempt to address (e.g. Bleeker et al., 2021). If we were forced to define what a paragraph is (e.g. through some computational function) and how it is build up from sub-structures (like glyphs, tokens, and sentences) we do exactly what Pichler and Reiter suggest and we define what we observe (interpret) by operationalising a process that identifies what we see.

4 Practical theory

In order to address the above concerns, the current proposal aims to take a significant epistemological step which makes data and provenance explicit; the singular advantage of such an approach is that the elements concerned are all comparable and evaluable by computation. It is our contention that a great drawback of previous theories and methods of digital editing is that they have, generally implicitly, relied on technologies which address the need of annotating strings of characters as available on, and thus constrained by, a standardised input device or keyboard. The scholar, therefore, observes textual phenomena, matches them up with available elements of

a specific finite set, and annotates strings of text. But of course, this already implies the existence of unacknowledged or at least unaccounted editorial judgement in the process of reading, interpretation, mapping, and reifying of the string before it is annotated. The existence of these unaccounted editorial judgements in current practice is implicitly acknowledged by the presence of such tags as “<precision>”, “<certainty>”, “<response>”, and their associated attributes, in the current TEI document model. Digital scholarly editions applying these tags have already one foot in the domain of the description of interpretative process. But the fact remains the same, this markup rather raises awareness that the underlying process of interpretation or reading was somehow complicated, but it does not try to model a process that was, maybe erroneously, conceived by the actor as being uneventful (cf. Kuczera & Kasper, 2019).

Furthermore, annotation of strings in this manner implies a missing link between, on the one hand, theory and phenomena, and on the other between the material source (in our case mediaeval manuscripts) and digital output. Additionally, the model of text presumed by such a process of annotation excludes a multiplicity of hierarchies, or, more precisely, foregrounds one such hierarchy - thereby resolving the problems of competing hierarchies and interpretations without even raising it. As such, processability, transparency and traceability are significantly lower than might be the case, given the power of current digital approaches to address this, and the self-imposed limitations imply a concomitant increased potential for error.

Scholarly editing in its current practical form for the most part gives rise to the recording of results and not to the recording of actions and processes. It is precisely the incorporation of this latter set of dimensions which lies at the root of the potentially transformative epistemological advance that we have in mind. Process and actions obviously require some actor, which may be human or technological. Following Luhmann (2013, p. 99) we note that: “one must always also have an observer in mind if one wants to say what is the case”. That is, what is regarded as a “fact” is dependent on the observational context and on the observer who is necessarily part of that context. Therefore, a philological practice that purports to be accountable for its interpretations needs to integrate the description of its interpretative acts and actors into the editions it produces as exhaustively as its technology feasibly allows for.

The epistemological step we propose in order to address this questions aims to place the ideo-hermeneutic input at the “lowest” level currently possible by presuming every layer is represented by a base-superstructure pair and it thus allows annotations to be organised in any number of non-hierarchical layers; describes and/or annotates documents and texts at any level of granularity and, crucially, acknowledges and seeks to allow for the incorporation of substructures and superstructures in any text. It is our contention that these epistemic changes and methodological revisions can best be accounted for at the level of glyph, and we therefore propose to begin precisely at this level by assigning a URI to each glyph. It should be noted, of course, that the level of glyph is not necessarily the lowest layer of substructures - we choose this level because at present, in a world of increasingly sophisticated HTR, the compilation of this level of data is likely to have a relatively low level of ideo-hermeneutic input. Thus, for

example, the URI assigned to the initial glyph in Fig. 1 contains information which includes, but is potentially not limited to, a range of different locators. Sub-structures could also be defined in individual URIs, as in the case of Fig. 2, in which the totality of the glyph can also encompass URIs which identify the individual scribal strokes which comprise the glyph.

The working process may be summarised as follows: every entity that is going to appear as an element in the proposed base-superstructure chain will have to be addressable by a unique URI. This approach is already well known from the overall scheme of the semantic web proposed decades ago. Below we propose a descriptive URI scheme that includes references to the digitization institution, the collection scheme, the page,

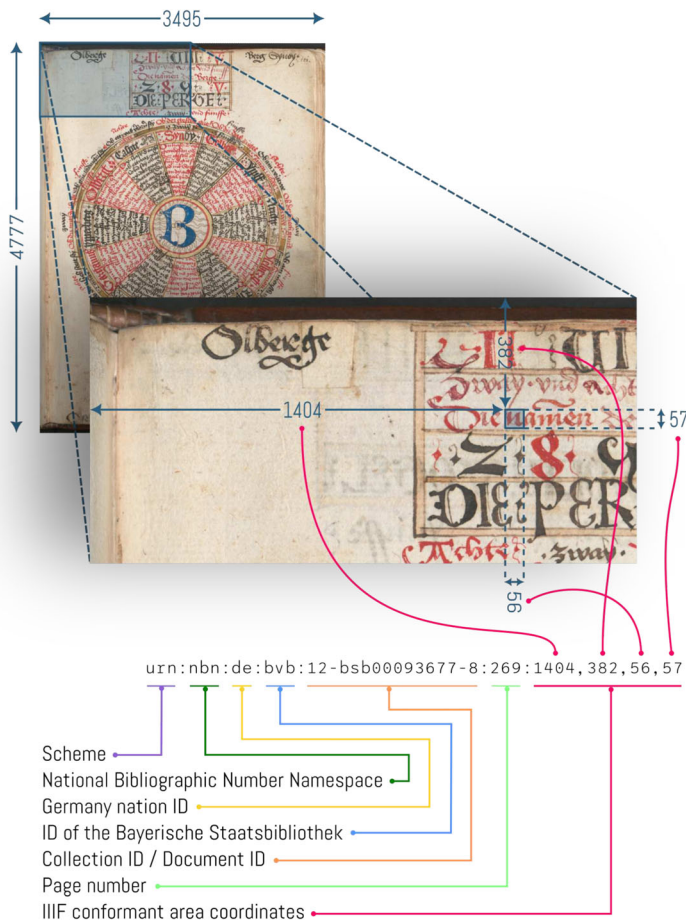
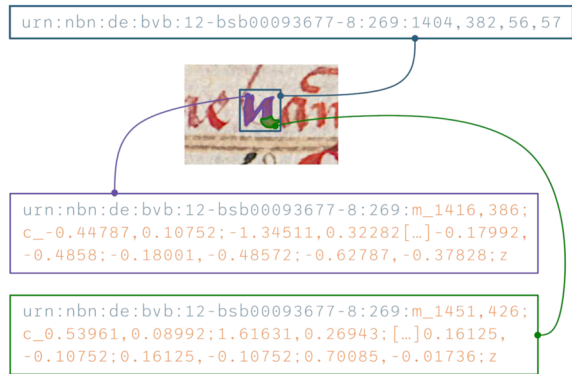


Fig. 1 Illustration of how Uniform Resource Identifiers (URIs) might uniquely address glyphs on a vellum of a manuscript. In this case the structure of the URI is meaningful and formatted as a Universal Resource Name (URN) that follows the National Bibliographic Number scheme (NBN). However, URIs need not at all be semantically meaningful. Any randomly generated identifier suffices, as long as it is unique. The unique URI is merely a token that allows us to retrieve further information about the object it identifies from some dedicated online service

Fig. 2 Any sub or super structure may be deconstructed into more granular components. This figure illustrate how on the sub glyph level individual pen strokes might be identified



and even the specific pixel coordinates of the canvas of the digitised media item in question. However, a unique randomly generated URI could serve the same purpose. In that case the URI merely becomes an identifier by which an URL can be dereferenced. A request sent to that URL then returns data with further information about the specific document region and its attributes. The representation and management of the digital manuscript and its constituents is realised by usage of IIIF. The pixel areas and geometries on the IIIF canvas are realised as IIIF annotations. These are then interlinked with RDF-resources representing the different readings based on different levels of granularity and interlinked in a meaningful way, e.g. individual glyphs are associated with the respective words they constitute. This last level of granularity (glyphs, words) may be based on the output of a HTR model, as long as the input image corresponds to a IIIF canvas. The RDF-resources as represented via the IIIF-APIs and the RDF-resources describing the constituents of the text also, may subsequently be merged within a triple store or a graph database.

It should be stressed that this is merely one possible technical implementation. Other technical standards and implementation might be used. The salient issue here is the principled choice for a super- and sub-structure solution that allows for arbitrary granularity and multi-perspectivity of description.

As can be seen from Fig. 3, one great advantage of this approach is that superstructures, in this case at token level, are therefore easily derivable from the substructures (and the definition of base, sub- and superstructure is contingent on the editor and edition in any case).

5 An example

By way of illustrative example, we choose a case in which the editor intends to normalise the orthography of a mediaeval text. The example is taken from the project for a computational edition of the mediaeval German versions of the sortes text 'Prenostica Socratis Basilei', a book of fortune with Arabic origins. Specifically, the excerpt presented here belongs to the manuscript München, Bayerische Staatsbibliothek, Cgm 312, f. 121r.

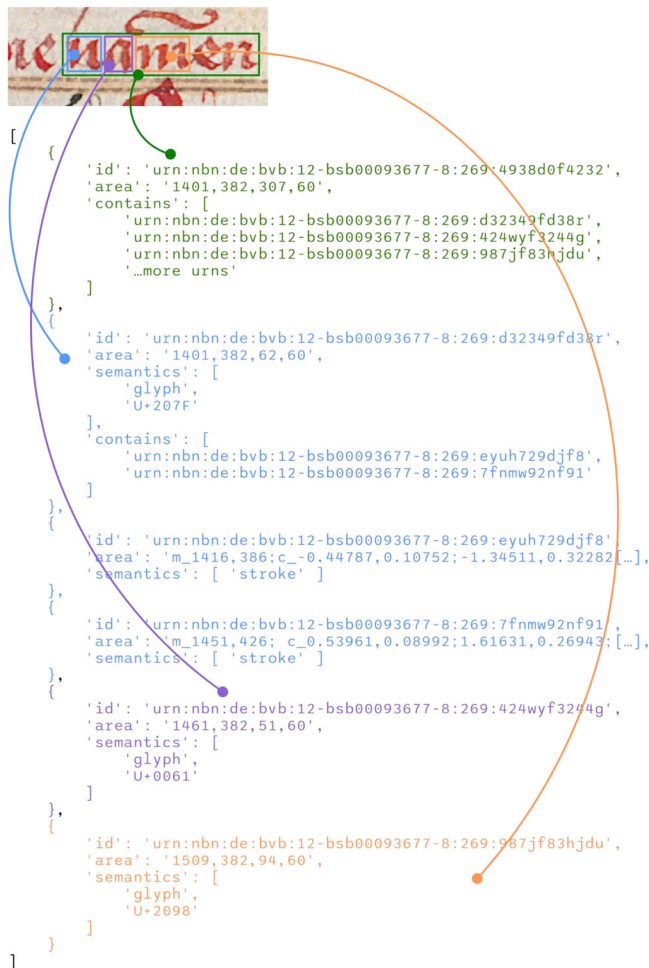


Fig. 3 Any sub or super structure may become part of another sub or super structure. There is no compulsory hierarchy, but only multiple ways of describing the various relations between structures. One formal way to do this, could be a JSON file that expresses which structures “contain” which others, as is suggested in this illustrations. However, many other digital technological inscriptions are possible to the same effect

Some information might help to contextualise the text under examination: the language used is East-Swabian, and the manuscript dates back to the years 1450-1473 (Heiles 2018, 239). The excerpt considered in this section is part of a circular layout composed of very short individual texts which contain instructions on how to proceed in the sortition process started at the beginning of the book of fortune (see Fig. 4). These books, the *sortes*, were used to predict the future: after choosing a question from a list, the user would use a randomising tool, such as dice, cards, or other devices, to determine the reading order of specific parts of the book. The latter could not therefore be read linearly, but required active participation in the creation of the reading chain

Fig. 4 München, BSB Cgm 312, f.121r



on the part of the user, who was supposed to go through different “stations” before receiving the answer by a figure functioning as an oracle.

The example shown in Fig. 5 instructs the reader to find the 8th line in the page dedicated to the King of Scotland (“So gee an 8 zeil zû dê kunig vō Schotfñ de? es [dir saget]”, meaning “so go to line 8 of the king of Scotland who [will tell you]”).

Also due to the very peculiar layout of these texts, which often present text in tables, circles and diagrams, it was necessary for scribes to make large scale use of abbreviations and to omit parts of the sentences.

Focusing now on the normalisation task, the editor intends to operationalise the process, following in the footsteps of Cugliana and Barabucci (2021), who introduced a method for automatising normalisations of mediaeval texts using XProc pipelines. However, while in that case the pipelines relied on substitutions based on probability rates in the composition of character strings and dealt with exceptions through manual corrections, in this case we intend to introduce a level of reasoning into the normalisation process, creating normalisation rules that take contextual information into consideration. In particular, such contextual information should not be limited to character co-occurrence but should also include annotations characterising single tokens.

Fig. 5 Excerpt from München, BSB Cgm 312, f. 121r



Considering in particular, for the sake of this example, the prepositional phrase “zû dê kunig”, an ambiguity arises concerning the expansion of “dê”, which in theory could be either “den” or “dem”, according to the possible endings in declination of the determinative article in East Swabian and the fact that the inverted breve (or the tilde, as often the diacritic signs are not clearly distinguished from each other) on the vowel “e” often stands for a nasal sound.

Now, the article in the prepositional phrase in question is preceded by the preposition “zu” (or “zu”), which requires the determiner and the noun to be in the dative case. Given that “kunig” is a singular masculine noun, the determiner will have to show the ending expressing the right morphological information (singular, masculine and dative). The expansion of the abbreviated article must be, therefore, “dem”. Being able to enrich the text with this type of metadata, in addition to other levels of annotation, makes it possible to address the necessary information in the creation of formalised rules such as “if the context is masculine singular and the preposition selects dative case, use the correspondent ending of the determinative article”.

To be able to include so many details in the metadata, it seems best to model the text as a graph. As a matter of fact, although it would probably be possible, performing some acrobatics, to include all this information in a TEI XML document, the result would be very hard to read and handle. Graph technologies instead facilitate the introduction of multiple, overlapping annotation layers which can independently refer to different aspects of text. Considering the example introduced before (“So gee an 8 zeil zû dê kunig ṽo Schotf̃n de? es [dir saget]”), we can represent this segment as a Neo4j graph, as is depicted in Fig. 6.

In this model, two chains of nodes are shown in parallel: the blue nodes represent the tokens (or the words), whereas the orange ones stand for the single glyphs. Of course, the number of levels that could be introduced in the graph depends on the individual choices of the editor and on the research question(s). So, for instance, the

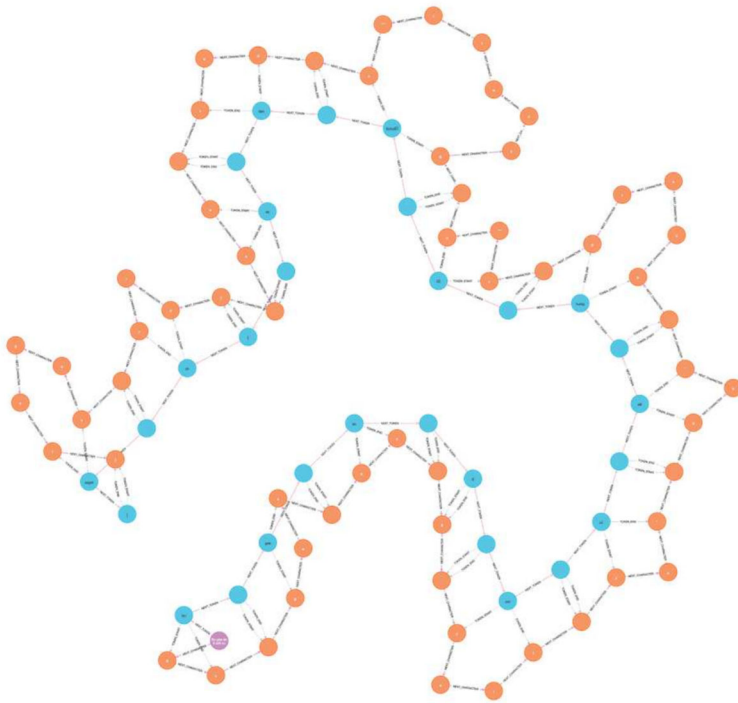


Fig. 6 Graph model in Neo4j of the segment “So gee an 8 zeil zû dê kunig v̇o Schotfñ de’ es [dir saget]”

prepositional phrase “zuo dem kunig”, whose graph portion is shown in Fig. 7, could be “summarised” in one single node, which in turn could be part of another “sentence node” and so on, without this giving rise to hierarchy based restrictions.

As was mentioned above, graph databases such as Neo4j support the introduction of different levels of annotations for each node or group of nodes. In Fig. 8, for instance, the token “dê” has a number of properties, such as the definition of the lemma (“der”), its modern German translation, a normalised version of the same token, a part of speech tagging saying that it is an article and a diplomatic rendition. Moreover, it is also associated with a URL pointing to the exact area on the facsimile page where the article in question is to be found.

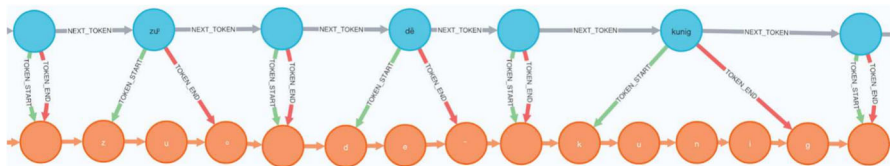


Fig. 7 Subgraph representing the prepositional phrase “zû dê kunig”

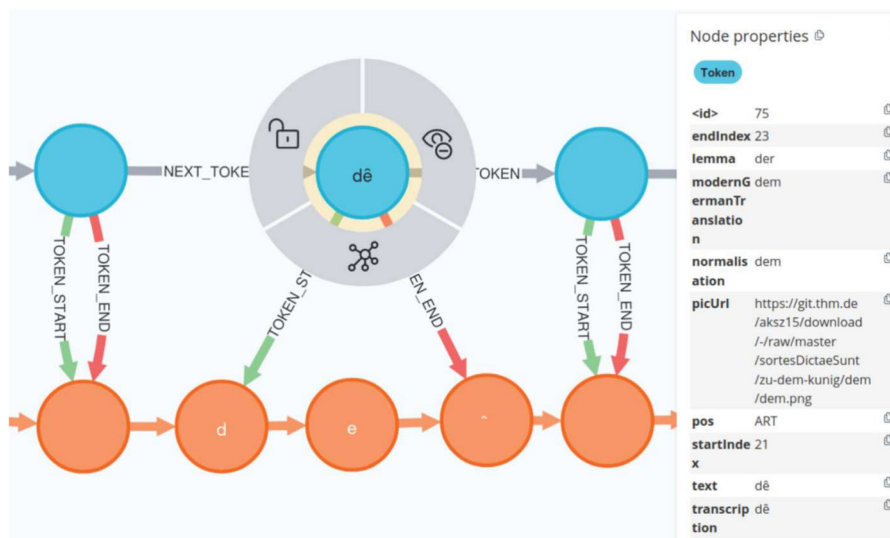


Fig. 8 Properties of the node ‘dē’ (token level)

Deepening the analysis, we can add properties to each of the glyphs composing this article. As the next figure shows (Fig. 9), it is possible to add annotations to each of the orange nodes: in the case of the glyphs, among the properties we also have a Unicode code point indicating exactly the digital representation chosen for the glyph. Also in the case of the single glyph, a URL connects the node to the exact coordinates on the facsimile where the glyph actually is.

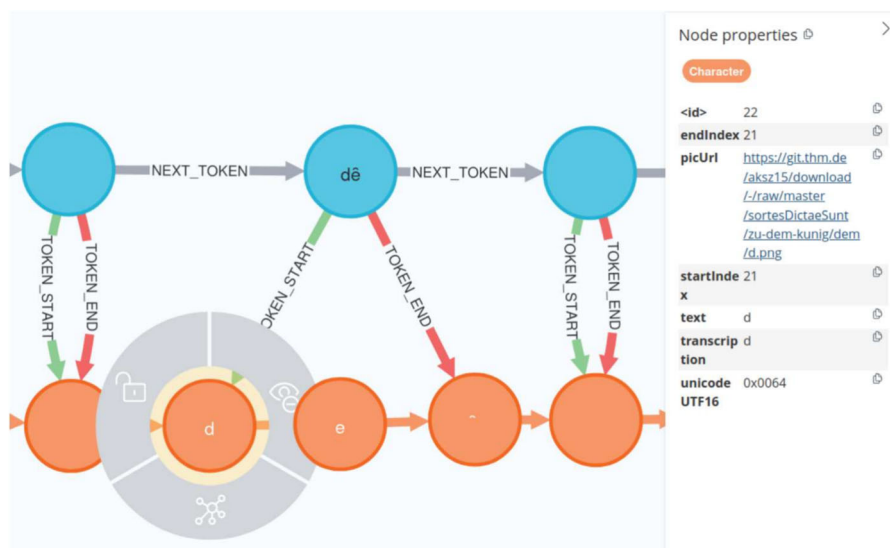


Fig. 9 Properties of the node “d” (glyph level)

6 Conclusion

The hypotheses which structured our argument were fundamentally based around the notion that “part of the reasoning [in the constitution of digital scholarly editions] will shift from implicit in the scholar to explicit in forms of code and explicit analysis, calculation, reasoning and logic”, and that this would necessarily have significant implications for the nature of authority, the requirement for transparency, the operationalising of workflow and, ultimately, the very nature and conceptualising of the works that we study. The example we provide here from our own practice, is not, of course, intended to be the last word in working out the practicalities of our hypotheses - quite the contrary, we intend such work-in-practice test case as a step in testing ways in which the conceptual and epistemological shifts alluded to might begin to be worked out in future praxis.

Our contentions are that:

- (i) both because technological advance permits an ever-multiplying relationality of data *and* because it represents more accurately the cognitive and conceptual processes of textual reading, modelling text for digital critical editing will involve the creation of knowledge graphs;
- (ii) data *and* assertions about those data will be at the core of such editions, and attribution of explicit provenance of both will be a *sine qua non* of their construction;
- (iii) the level of transcription and data construction in which the lowest level of ideohermeneutic input will be required, and at which, therefore, the greatest level of purely algorithmic recognition takes place, is that of the glyph - assuming that each glyph has its own URI allows for the greatest number of significantly usable nodes and edges with a concomitant fine-grained possibility of meaningful annotation of a range of different classes of data and knowledge;
- (iv) finally, since any chosen unit will be addressable, it becomes possible to operationalise actions and processes at the core of editing (such as normalisation, collation, analysis etc.).

We are of course aware of many implications of this approach. There are major ethical questions associated with explicit and transparent provenance; the use of glyphs as a baseline for transcription is not a panacea since they too imply a certain level of human interpretation; the nature of rule-based approaches (or not) in the context of increasing use of Artificial Intelligence has myriad implications for the methodology of digital textual editing.

Nonetheless, it is our view that formalising and operationalising the editorial workflow in the manner outlined above has significant analytical and epistemological potential, not least for our knowledge and understanding of the sources we edit and our own philological processes. The corraling of different classes of data, in contingent manner and for the purposes of a specific edition, relies on those data being created and organised in such a way as to allow for their creative connection and interpretation. The resulting editions are necessarily qualitatively different from those produced in

print. But this not only changes the nature of the edition, it also implies a different conception of the very object of study in the first instance.

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Declarations

Competing of Interest The authors declare no competing interests.

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References

- Andrews, T. (2023). The structured assertion record (star) model for event-based representation of historical information. In: Graphnr 2023: Graphs and networks in the fourth dimension - time and temporality as categories of connectedness, (pp. e:32). Mainz: Academy of Sciences and Literature. [2024-05-23] <https://graphentechnologien.hypotheses.org/files/2023/05/GraphNR-2023-32-Andrews-STAR.pdf>
- Andrews, T.L. (2013). The third way: Philology and critical edn in the digital age. *Variants* 10, 61–76
- Armstrong, R.H. (2016). A Wound, not a World. Textual Survival and Transmission. In: M. Hose and D. Schenker (Eds.), *A Companion to Greek Literature*, (pp. 27–40). Chichester: John Wiley & Sons.
- Berry, D. M., & Fagerjord, A. (2017). *Digital Humanities Knowledge and Critique in a Digital Age*. Cambridge, Malden: Polity Press.
- Bleeker, E., Haentjens Dekker, R., Buitendijk, B. (2021), Texts as hypergraphs: An intuitive representation of interpretations of text. *Journal of the Text Encoding Initiative*, 14:e:3919. <https://doi.org/10.4000/jtei.3919>
- Bod, R. (2015). The Importance of the History of Philology, or the Unprecedented Impact of the Study of Texts. In: T. Kalmthour and H. Zuidervaart (Eds.), *The practice of philology in the nineteenth-century Netherlands* (pp 17–36). Amsterdam: Amsterdam University Press. [2024-05-23] <https://muse.jhu.edu/book/66452>
- Bode, K. (2023). What's the matter with computational literary studies? *Critical Inquiry*, 49(4), 507–529. <https://doi.org/10.1086/724943>
- Boot P, et al (Eds.). (2017) *Advances in Digital Scholarly Editing: Papers Presented at the Dixit Conferences in the Hague, Cologne, and Antwerp*. Leiden: Sidestone Press. [2021-02-25] <https://www.sidestone.com/books/advances-in-digital-scholarly-editing>
- Bordalejo, B. (2018). Digital versus analogue textual scholarship or the revolution is just in the title. *Digital Philology: A Journal of Medieval Cultures*, 7(1), 7–28. <https://doi.org/10.1353/dph.2018.0001>
- Borgman, C. L. (2015). *Big Data, Little Data, No Data: Scholarship in the Networked World*. Cambridge, London: The MIT Press.
- Brennan, T. (2017). The digital-humanities bust. *The Chronicle of Higher Education*, 64(8), e:1. [2017-10-28] <http://www.chronicle.com/article/The-Digital-Humanities-Bust/>
- Bridgman, P. W. (1927). *The Logic of Modern Physics*. New York, USA: Arno Press.
- Buzzetti, D. (2002). Digital representation and the text model. *New Literary History*, 33(1), 61–88.

- Buzzetti, D., McGann, J. (2006) Critical editing in a digital horizon. In: L. Burnard, K. O'Brien O'Keefe, and J. Unsworth (Eds.), *Electronic textual editing*, (pp. 53–73). New York: Modern Language Association of America. <http://www.tei-c.org/Activities/ETE/Preview/index.xml>
- Crane, G. (2006). What do you do with a million books?. *D-Lib Magazine*, 12(3), 3. [2012-04-16] <http://www.dlib.org/dlib/march06/crane/03crane.html>
- Cugliana, E., Barabucci, G. (2021) Signs of the times: Medieval punctuation, diplomatic encoding and rendition. *Journal of the Text Encoding Initiative*, (Issue 14), e:3715. <https://doi.org/10.4000/jtei.3715>
- Dahlström, M. (2008). The Compleat Edition. In M. Deegan & K. Sutherland (Eds.), *Text editing, print and the digital world (digital research in the arts and humanities)*, (pp. 27–44). Ashgate.
- DeRose, S. J., Durand, D. G., Mylonas, E., & Renear, A. H. (1990). What is text, really? *Journal of Computing in Higher Education*, 1(2), 3–26.
- Eggert, P. (2009). *Securing the Past: Conservation in art, Architecture and Literature*. Cambridge: Cambridge University Press.
- Eggert, P. (2019). *The Work and the Reader in Literary Studies: Scholarly Editing and Book History*. Cambridge: Cambridge University Press. [2021-04-27] <https://www.cambridge.org/core/books/work-and-the-reader-in-literary-studies/F9FD2AC33A78BCF5A670BE71C9A7045E>
- Fickers, A. (2020). Update für die Hermeneutik. Geschichtswissenschaft auf dem Weg zur digitalen Forensik?. *Zeithistorische Forschungen – Studies in Contemporary History*, 17(1), 157–168. <https://doi.org/10.14765/zzf.dok-1765>
- Haentjens Dekker, R., Birnbaum, D.J. (2017). It's more than just overlap: Text as graph. In: *Proceedings of Balisage: The markup conference 2017*, (vol. 19). Washington, DC. [2018-03-05] <https://www.balisage.net/Proceedings/vol19/print/Dekker01/BalisageVol19-Dekker01.html>
- Heinzle, J. (2003). Zur Logik mediävistischer Editionen. *Editio* (2003), 17(2003), 1–15. <https://doi.org/10.1515/9783484604544.1>
- Heßbrüggen-Walter S (2020) Positivismus der geistigen Gegenstände: Carnap und die Digital Humanities. *Digital Humanities im deutschsprachigen Raum*, (pp. 182–184). Paderborn: Universität Paderborn.
- Institut für Dokumentologie und Editorik (2022). Manifest für digitale Editionen. [2024-03-14] <https://dhd-blog.org/?p=17563>
- Karjus, A. (2023). Machine-assisted mixed methods: augmenting humanities and social sciences with artificial intelligence. <https://doi.org/10.48550/arXiv.2309.14379>(preprint)
- Kirsch, A. (2014). Technology Is Taking Over English Departments: The false promise of the digital humanities. *New Republic*, pp. e:1. [2014-05-08] <http://www.newrepublic.com/article/117428/limits-digital-humanities-adam-kirsch>
- Kuczera, A., Kasper, D. (2019). Modellierung von Zweifel - Vorbild TEI im Graphen. *Zeitschrift für digitale Geisteswissenschaften*, Sonderbände 4 «Die Modellierung des Zweifels - Schlüsselideen und -konzepte zur graphbasierten Modellierung», pp e:sb004_003. <https://doi.org/10.17175/sb004sps003>
- Luhmann, N. (2013) Introduction to Systems Theory. In: (D. Baecker, P. Gilgen,). Cambrdige: Polity Press. (First published in German as “Einführung in die Systemtheorie”, Carl-Auer-Systeme Verlag, 2002.)
- Macé C, Amphoux C-B, Nesselrath H-G, Duval F, Plate R, Bausi A, Van Hulle D (2020) Chapter 7: Philological practices. In: P. Roelli (Ed.), *Handbook of Stemmataology*, (pp. 437–533). Berlin, Boston: De Gruyter. [2020-04-22] <https://www.degruyter.com/view/title/569065>
- McGann, J. (2013). Philology in a new key. *Critical inquiry*, 39(2), 327–346. <https://doi.org/10.1086/668528>
- Meister, J.C. (2022). Annotation als Markup avant la lettre. In F. Jannidis (Ed.), *Digitale Literaturwissenschaft: DFG-Symposion 2017* (pp. 353–383). Stuttgart: J.B. Metzler.
- Neill, I., Kuczera, A. (2019) The Codex – an Atlas of Relations. *Zeitschrift für digitale Geisteswissenschaften*, Sonderbände 4 «Die Modellierung des Zweifels - Schlüsselideen und -konzepte zur graphbasierten Modellierung», e:sb004_008. <https://doi.org/10.17175/sb004sps008>
- Pichler, A., Reiter, N. (2022). From concepts to texts and back: Operationalization as a core activity of digital humanities. *Journal of Cultural Analytics*, 7(4), e:001c.57195. <https://doi.org/10.22148/001c.57195>
- Pollock, S. (2009). Future philology? the fate of a soft science in a hard world. *Critical inquiry*, 35(4), 931–961. <https://doi.org/10.1086/599594>
- Puppo, M. (1968). *Manuale Critico Bibliografico per lo Studio della Letteratura Italiana (vol III L'edizione critica)*. Torino: Società Editrice Internazionale.
- Robinson, P. (2016). The digital revolution in scholarly editing. *Ars Edendi Lecture Series*, 4(116), 181–207.
- Roelli, P. (Ed.). (2020). *Handbook of Stemmataology*. Berlin, Boston: De Gruyter. [2020-04-22] <https://www.degruyter.com/view/title/569065>

- Sahle, P. (2010). Zwischen Mediengebundenheit und Transmedialisierung. *Editio*, 24(2010), 23–36. <https://doi.org/10.1515/9783110223163.0.23>
- Sahle, P. (2013a) *Schriften des Instituts für Dokumentologie und Editorik: vol. 8. Digitale Editionsformen. Teil 2: Befunde, Theorie und Methodik* (No. 8). Norderstedt: BoD – Books on Demand.
- Sahle, P. (2013b) *Schriften des Instituts für Dokumentologie und Editorik: vol. 8. Digitale Editionsformen. Teil 3: Textbegriffe und Recodierung* (No. 9). ed: BoD – Books on Demand.
- Stella, F. (2018). Bussola: vol. 563. Testi letterari e analisi digitale. Roma: Carocci editore.
- Van Zundert, J.J. (2016). Barely Beyond the Book?. In: M.J. Driscoll and E. Pierazzo (Eds.), *Digital Scholarly Editing: Theories and Practices*, (pp. 83–106). Cambridge: Open Book Publishers. [2016-08-24]<http://www.openbookpublishers.com/reader/483>
- Van Zundert, J. J. (2019). Why the compact disc was not a revolution and «Cityfish» will change textual scholarship, or what is a computational edition? *Ecdotica*, 15, 129–156.
- Van Zundert, J.J., Andrews, T.L. (2017). Qu'est-ce qu'un texte numérique?. *Digital Scholarship in the Humanities*, 32(Suppl_2), ii89–ii105. <https://doi.org/10.1093/lc/fqx039>
- Vogeler, G. (2021). Standing-off trees and graphs: On the affordance of technologies for the assertive Edn. In: E. Spadini, F. Tomasi, and G. Vogeler (Eds.), *Schriften des Instituts für Dokumentologie und Editorik: vol.15. graph data-models and semantic web technologies in scholarly digital editing* (pp 73–94). Norderstedt: BoD – Books on Demand.

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