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Network Analysis of Religious Texts. Case Studies on Ancient Egyptian and Indian Religion

Introduction: Dipping into the Ocean of Digital Humanities

In this essay, I recapitulate the genesis and the development of the SeNeReKo project[1]. While I had an interest in technology and programming before, SeNeReKo was the first real project that would intersect my research in religion and my interest in technology. It was initiated by a grant scheme by the German ministry for education and research that targeted as the then-called "eHumanities."[2] It invited applications for projects where researchers from the humanities and the qualitative branch of social sciences would partner with researchers from computer science in order to advance their studies. The call was interesting for two reasons: Firstly, in contrast to earlier funding schemes that focused on digitization, this one looked for projects that would use previously digitized resources to answer actual research questions. Secondly, these research questions should be rooted in the humanities and social sciences, with computer science and other technical disciplines providing tools that allow for new methodological approaches—thus "enhanced humanities."

Digital humanities (DH) were already a thing in 2011, with the first ADHO conference being held as early as 1989,[3] but for me this was my first contact with the field. It is also probably fair to say that in the years since then the contours of DH as a discipline became much clearer, especially in the German con-

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[1] The SeNeReKo project was funded by the German Federal Ministry of Education and Research under the project number 01UG1242 A. The author of this paper is responsible for its content.
[2] Bundesministerium für Bildung und Forschung, "Bekanntmachung des Bundesministeriums für Bildung und Forschung von Richtlinien zur Förderung von Forschungs- und Entwicklungsvorhaben aus dem Bereich der eHumanities," May 10, 2011, https://web.archive.org/web/20180214170128/https://www.bmbf.de/foerderungen/bekanntmachung-643.html.
[3] Alliance of Digital Humanities Organizations, "Conference," accessed July 13, 2019, https://web.archive.org/web/20190713044353/http://adho.org/conference.

text.[4] But at its inception, our project did not position itself as part of the DH per se. Our starting point was the application of network analysis methods to the study of religions. Network analysis is a popular part of the methodological canon of DH.[5] At the same time, there are many different lines of research in how network analysis is applied in the humanities. A comprehensive overview is beyond the scope of this article, but I will briefly sketch out some of the dominant strands what were relevant for developing our approach.

The study of religions in its current form is methodologically hybrid. It has a strong philological tradition, but it is also interested in historical developments beyond the text, and increasingly engages with contemporary phenomena, using methods from the social sciences. Similarly, very different traditions of network analysis can potentially be applied to study religions. A strong tradition of network analysis exists in social sciences, where it is called Social Network Analysis (SNA).[6] Increasingly, SNA has also been applied to historical phenomena in the form of Historical Network Research (HNR). A prominent use case are early modern correspondence networks, e.g. the "republic of letters."[7] Like in SNA, in HNR still individual persons (and sometimes organizations) and their interactions are the main constituents of the network. The further back in history you go, the sparser the evidence about individuals. Still, archeology has been actively adopting network analysis, though more often based on the connections that can be reconstructed or assumed between historical places.[8] A second field increasingly embracing network analysis are literary studies.[9] An influential early essay in

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4 The German association DHd was founded 2013, its first conference took place in 2014. See digital humanities im deutschsprachigen raum, "Über DHd," accessed April 21, 2019, https://web.archive.org/web/20190421064131/http://dig-hum.de/ueber-dhd.

5 See e.g. Scott B. Weingart, "Demystifying Networks, Parts I & II," *Journal of Digital Humanities* 1, no. 1 (2011), http://journalofdigitalhumanities.org/1-1/demystifying-networks-by-scott-weingart/.

6 See e.g. John Scott, *Social Network Analysis: A Handbook* (1–1), 2nd ed. (Los Angeles [u.a.]: Sage, 2009); David Knoke and Song Yang, *Social Network Analysis*, 2nd ed., Quantitative Applications in the Social Sciences 154 (Los Angeles [u.a.]: SAGE Publ, 2008).

7 Caroline Winterer, "Where Is America in the Republic of Letters?" *Modern Intellectual History* 9, no. 3 (2012): 597–623, doi:10.1017/S1479244312000212.

8 For an application with regard to religion, see e.g. Anna Collar, "Re-Thinking Jewish Ethnicity Through Social Network Analysis," in *Network Analysis in Archaeology: New Approaches to Regional Interaction*, ed. Carl Knappett (Oxford University Press, 2013), 223–45. For a broader overview, see Anna Collar et al., "Networks in Archaeology: Phenomena, Abstraction, Representation," *Journal of Archaeological Method and Theory* 22, no. 1 (2015): 1–32, doi:10.1007/s10816-014-9235-6.

9 Peer Trilcke, "Social Network Analysis (SNA) als Methode einer textempirischen Literaturwissenschaft," in *Empirie in der Literaturwissenschaft*, ed. Philip Ajouri, Katja Mellmann, and Christoph Rauen, Poetogenesis 8 (Münster: mentis, 2013), 201–47.

this regard was "Network Theory, Plot Analysis" by Franco Moretti.[10] Especially stage plays have been studied using network analysis approaches, but also novels and other literary works can be analyzed using SNA. A very different application of network analysis can be found in linguistics, especially corpus linguistics and computational linguistics. Here, not (actual) people or (fictional) characters are the elements of the network, but words. The network does not model social systems, but language. This can be used to find out more about the historical meaning of a word and its change by looking at the context words it appears together with.[11] All these different approaches can be fruitful for the study of religions, as we study contemporary and historical persons, accounts of mythical figures and transcendent beings in religious texts, but also discourse and the historical meaning of certain concepts, including religion itself.

I myself had been introduced to network analysis methods a while ago by Alexander Nagel for whom I had briefly worked in a project on EU policy networks.[12] For his work, he had developed a semiotic method of structural connotation.[13] This method could be used to identify actors in texts and the different kinds of relations between the actors that the texts talked about. Using that information, one could extract network data and perform network analysis. His method relied on manual content analysis, so in the end a researcher would go through collections of texts and identify actors and their relations. I was interested to see if this could be automated through the use of computational methods.

The Center for Religious Studies (CERES) at the Ruhr University Bochum was a great place to develop a project like this. The Center's director and my PhD supervisor, Volkhard Krech, supported the project from the beginning and provided valuable input with regard to the theoretical framework. But we also needed scholars who worked with large text collections and were willing to try out

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10 Franco Moretti, "Network Theory, Plot Analysis," *New Left Review*, no. 68 (2011): 80–102, https://newleftreview.org/II/68/franco-moretti-network-theory-plot-analysis.

11 See e.g. Alexander Mehler et al., "Inducing Linguistic Networks from Historical Corpora: Towards a New Method in Historical Semantics," in *New Methods in Historical Corpora*, ed. Paul Bennett et al., Korpuslinguistik Und Interdispiplinäre Perspektiven Auf Sprache 3 (Tübingen: Narr, 2013), 257–74.

12 See Alexander-Kenneth Nagel, *Politiknetzwerke und politische Steuerung: institutioneller Wandel am Beispiel des Bologna-Prozesses*, Staatlichkeit im Wandel 12 (Frankfurt am Main: Campus, 2009).

13 Alexander-Kenneth Nagel, "Analysing Change in International Politics: A Semiotic Method of Structural Connotation," TranState Working Papers (University of Bremen, Collaborative Research Center 597: Transformations of the State, 2008), http://hdl.handle.net/10419/24983.

new methods of approaching them. We found them in Beate Hofmann, an Egyptologist who had worked on structural genre analysis, and Sven Wortmann, who was working on a PhD project on interreligious contact during the early Buddhist period. Later in the project, Egyptologist Simone Gerhards and Indologist Sven Sellmer joined the team. For the part of Egyptology, a database of various hieroglyphic texts existed at the Berlin-Brandenburg Academy of Sciences and Humanities, the Thesaurus Linguae Aegyptiae (TLA) (http://aaew.bbaw.de/tla/). For the project on Buddhism, the Pāli Canon existed in digital form, like the one provided by the Vipassana Research Institute.[14]

Structure and Semantics, or: Structure of Semantics

One of CERES' main areas of research is interreligious contact in Eurasian history of religions. We are interested in the conditions, modes and consequences of interreligious encounter. So it was a natural starting point to look for descriptions of interreligious encounter and analyze how they were described in the texts. The Pāli Canon seemed to be a good example for this, as it contains a series of encounters between the Buddha and members of other religious groups. But also Ancient Egyptian sources contained descriptions of other peoples.

An analytical distinction between structure and semantics served as a theoretical framework.[15] On the one hand we were interested in seeing the structural relations between various groups and actors, something network analysis seemed well suited for. But structural formations alone probably will not explain the dynamics of religious history. A layer of semantics in the sense of "ideas"

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14 *Pāli Tipiṭaka*, http://tipitaka.org/. For a more detailed review of the digital resources availble for Buddhist studies, see Bingenheimer's chapter in this volume.

15 See Volkhard Krech, "Dynamics in the History of Religions. Preliminary Considerations on Aspects of a Research Programme," in *Dynamics in the History of Religions Between Asia and Europe in Past and Present Times*, ed. Volkhard Krech and Marion Steinicke (Leiden: Brill, 2012), 15–70, p. 27. The terms "structure" and "semantics" are borrowed from systems theory, see e.g. , Rudolf Stichweh, "Semantik und Sozialstruktur: Zur Logik einer Systemtheoretischen Unterscheidung," *Soziale Systeme. Zeitschrift für Soziologische Theorie* 6, no. 2 (2000). Similar distinctions are common in the sociology of religions. See e. g. Max Weber's distinction between "ideas" and "interests" in Max Weber, "Die Wirtschaftsethik der Weltreligionen. Vergleichende religionssoziologische Versuche. Einleitung," in *Max Weber Gesamtausgabe*, vol. 19 (1920; repr., Tübingen: Mohr Siebeck, 1989), 101. See also Georg Simmel's distinction between "content" and "form" in Georg Simmel, *Soziologie. Untersuchungen über die Formen der Vergesellschaftung* (Leipzig, Duncker & Humblot, 1908), 5–6.

also has to be taken into account: Of what sort are the relations between actors? How do they talk about each other? What are the abstract concepts they refer to? Nagel's method accounted for a basic level of semantic annotation by differentiating between different types of relations, e. g. legitimization, cooperation or financial transaction. But this requires to define a set of possible relation types in advance. In contrast, we wanted to study the semantics used in the religious sources themselves, and thus try a more inductive approach that would *discover* emic categories instead of *defining* etic ones. So in a sense, we did not only want to study structure and semantics of religious encounter, we also wanted to study the structure *of* semantics in historical religious sources.

As a technical partner, we chose the Trier Center for Digital Humanities. They had a lot of experience with preparing digital editions from historical sources, so we were confident they could help us answer new questions based on the sources that were accessible to us.

The Basics I: Network Analysis

Our goal was to analyze relations—between actors, but also between actors and ideas. The method we wanted to apply for this purpose was network analysis. Without going too much into the methodological details here, I want to give a brief overview of what network analysis is and how it matched our aims.

Network analysis is a method for studying relational data. Relational data allow us to answer different kinds of questions. In traditional statistical datasets, we usually have distinct elements, e. g. persons, and their attributes, e. g. age, gender and income. This allows us to answer questions like "do you earn more the older you get?" or "do men earn more than women?" In contrast, relational data contain information about the position of an element in relation to all the other elements. This allows us to answer questions like "who is the most central actor in a network?" or "which sub-groups can I observe in the larger system?"

Humanities questions can often be phrased in relational term: We usually think of cultural systems as woven nets and entangled processes.[16] However, this perspective often remains metaphorical: We use a regulative idea of webs or networks, but we don't use formal methods that operationalize the metaphor.

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16 For a history of the metaphor, see Sebastian Giessmann, *Netze und Netzwerke: Archäologie einer Kulturtechnik, 1740–1840* (Bielefeld: Transcript, 2006).

Network analysis in its strict sense[17] uses a formal mathematical model of what a network is: In its most basic sense, a network consists of distinct elements, the "nodes," and relations between them, the "edges." This simple model already enables a series of calculations that can answer questions about the network as a whole or about the position of individual nodes. Extensions of this most basic network model cover varying strength of relations ("edge weight"), directions of relations ("A likes B, but B doesn't like A", "directed network"), different types of relations like "personal" or "professional" ("multiplex networks"), or different types of nodes, e.g. "persons" and "ideas" ("multi-modal networks").

In social networks, the model can be applied in a straight-forward manner: People are nodes, and relations between them form the edges. This still requires a series of decisions during research design, e.g., how do I observe relations? Do I ask people about their friends, and if so, what do they understand as friendship? What are the limits of a network, an organization, a country, or potentially the whole world? But in the case of cultural networks that include abstract ideas in general, and in religious networks in particular, these questions become even more difficult: Are non-physical entities (e.g., gods or ancestors) parts of the network? What is the place of an "idea" in a network, is it a quality of the relations (as different edge types) or are they distinct nodes? If the latter, what is an "idea?"

Additionally, we wanted to generate these networks from textual sources in an automated manner. The kind of hermeneutic work that a researcher could bring in, as in Nagel's approach, had to be translated into a simple set of rules—or at least into something a computer could infer from the data.[18] But in order for a computer to understand what is going on in a text, we needed the computer to understand more about language: What are the meaning bearing words in a sentence (e.g., nouns, adjectives and verbs in contrast to particles)? How are relations between those elements expressed?

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17 There is a discussion about "qualitative network analysis" as a method that does not use formal network analysis methods, but still uses a relational perspective as its methodological basis. See e.g. Betina Hollstein, "Qualitative Approaches," in *The Sage Handbook of Social Network Analysis*, ed. Peter J. Carrington and John Scott (Los Angeles: Sage, 2011), 404–16.

18 When we started, we knew little about the possibilities of recent machine learning algorithms. They change quite drastically how we think of the computer's work, because they allow us to teach a machine by examples, as we would instruct human encoders, instead of formulating deterministic rules.

The Basics II: Linguistic Groundwork and Data Preparation

Working with text on a linguistic level—instead of, e.g., a simple full-text search—requires thorough data preparation.[19] A project requirement was that the text collections we used had to be digitized already. So at least we did not have to scan or photograph texts, apply OCR or handwriting recognition, or things like these which often are required when working with sources beyond the large digitized text collections. But the level of additional linguistic information was very different between the collections.

The TLA contained manual annotations for the Egyptian texts. The edited texts were split into sentences and words—not a trivial task for a language with no punctuation or spaces. Each word was linked to the corresponding *lemma* (base form) in a dictionary which already accounted for different senses of a single word. Additionally, each word carried detailed information about its morphology, e.g. part of speech, gender, or number. However, the information was encoded in an arcane system of numerical codes that was developed some twenty years ago when the work on the TLA started. So in order to make use of the information, we first had to decipher these codes with the help of a lengthy manual—and the patient support of the colleagues from the Berlin-Brandenburg Academy. We completely underestimated the effort that was required to simply use the information that was already there. On the other hand, we had a series of fruitful conversations with colleagues from multiple Egyptological research projects about a more accessible, shared encoding schema that would help projects like ours in the future.[20]

The Pāli Canon, on the other hand, was available with only minimal markup. Visible elements like section headings or verse were identifiable, but no linguistic information was given. In order to get linguistic information about the text, we decided to re-use existing tools from computational linguistics to automatically enrich the textual markup. But since—to our knowledge—no one previously developed a part-of-speech tagger for Pāli, we had to train one ourselves.[21] This

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19 See Krawiec's and Schroeder's chapter on Coptic Scriptorium in this volume for an example of the required steps for building a digital corpus.

20 Laurent Coulon et al., "Towards a TEI Compliant Interchange Format for Ancient Egyptian-Coptic Textual Resources" (Annual Meeting of the TEI Consortium: Connect, Animate, Innovate, Lyon, 2015), http://orbi.ulg.ac.be/handle/2268/187518.

21 Modern part-of-speech taggers work for multiple languages. In order to add support for a new language, the basic program itself does not have to be modified. Instead, the program is

required substantial work by the Indologist on our Team, Sven Wortmann, and his student, Manuel Pachurka. We had a partially completed version at the end of the project. We learned a lot about the current state of linguistic tools,[22] but we finished that part of the work too late to actually analyze the canon with regard to our original research questions.

Luckily, we received a generous "data donation" from Indologist and computational linguist Oliver Hellwig. He had developed a lemmatizer and part-of-speech tagger for Sanskrit[23] and provided us with an automatically annotated version of the Indian epic Mahābhārata. This allowed us to analyze an important text from Indian religious history, albeit a different one than originally planned.

In retrospect, we substantially underestimated the amount of work that went into data preparation and technical infrastructure. The computer scientist on the team, Jürgen Knaut, spent a considerable amount of work on data transformation and programming tools that allowed us to prepare the texts for automatic processing. On the one hand, this cost us time we would have rather spent on actually working on our research questions. On the other hand, we all learned a lot in terms of text annotation and interoperability. This knowledge has already proven itself helpful in different occasions, and generally seems to be increasingly important for digitization projects—a development that hopefully will make it easier for projects that come after ours to make use of the ever-growing treasure of digitized sources.

Methods: Network Generation and Analysis

Our goal was to automatically extract networks from the text corpora. Those networks could then be analyzed using standard network analysis tools. We experimented a lot with different approaches.

One of the major questions was to determine what we wanted to see as "nodes" in our networks: Do we aim at social network analysis and regard

provided with a manually encoded subset of the text from which it "learns" the rules it then applies to the rest of the corpus.

22 See Frederik Elwert et al., "Toiling with the Pāli Canon," in *Proceedings of the Workshop on Corpus-Based Research in the Humanities*, ed. Francesco Mambrini, Marco Passarotti, and Caroline Sporleder (Warsow, 2015), 39–48, http://crh4.ipipan.waw.pl/index.php/download_file/view/13/152/.

23 Oliver Hellwig, "Performance of a Lexical and POS Tagger for Sanskrit," in *Sanskrit Computational Linguistics*, ed. Girish Jha (Berlin / Heidelberg: Springer, 2010), 162-72, doi:10.1007/978-3-642-17528-2_12.

only persons as nodes? In that case, do we include gods and other transcendent beings? Or do we choose a semantic network approach where we also include more abstract concepts as nodes, allowing to track the position of ideas in the network? Answering this question depended not only on methodological and technical considerations, but also on the characteristics of the texts: In order to get a meaningful person network, we would want a fixed set of persons whose repeated interactions are described in the text. In the case of the Egyptian texts, we often had tomb inscriptions describing the relation of the decedent to the gods. Here, the chance of finding mentions of the same person again were relatively slim. More promising were narratives like "the contendings of Horus and Seth"[24]. These stories, however, were often relatively short, making them less suitable for computational analysis. In contrast, the Pāli canon frequently mentions interactions between the Buddha and more or less random people he meets during his journey. Those people then were also only mentioned once in the description of that particular encounter, while the Buddha appeared over and over again. As a network, this would result in a star-like figure: The Buddha in the center with relations to various other persons who themselves have little or no relations to each other.

A Semantic Social Network of the Mahābhārata

On the other hand, the Mahābhārata turned out to be fit for this type of personal network analysis: It is mainly a continuous and coherent narrative with limited *dramatis personae* and repeated interactions between the parties. This allowed us to construct a social interaction network from the Mahābhārata. We used a very simple heuristic in order to determine if two persons have some sort of connection and thus should be linked through an "edge" in the network: If any two persons were mentioned within the same verse (usually two lines), we added an edge between them. This already revealed interesting patterns: By applying standard network analysis measures like degree centrality, we could identify the central actors of the narrative. More interestingly, applying a community detection algorithm[25] also revealed the major factions of the narrative: The gods are identified as one coherent group (with the exception of Yama, the god of death, who

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24 Chester Beatty I, recto (Dublin, Chester Beatty Library).

25 Vincent D. Blondel et al., "Fast Unfolding of Communities in Large Networks," *Journal of Statistical Mechanics: Theory and Experiment* 2008, no. 10 (2008): P10008, doi:10.1088/1742-5468/2008/10/P10008.

is more closely linked to the main protagonists), as are groups of heroes with particularly close relations among themselves.
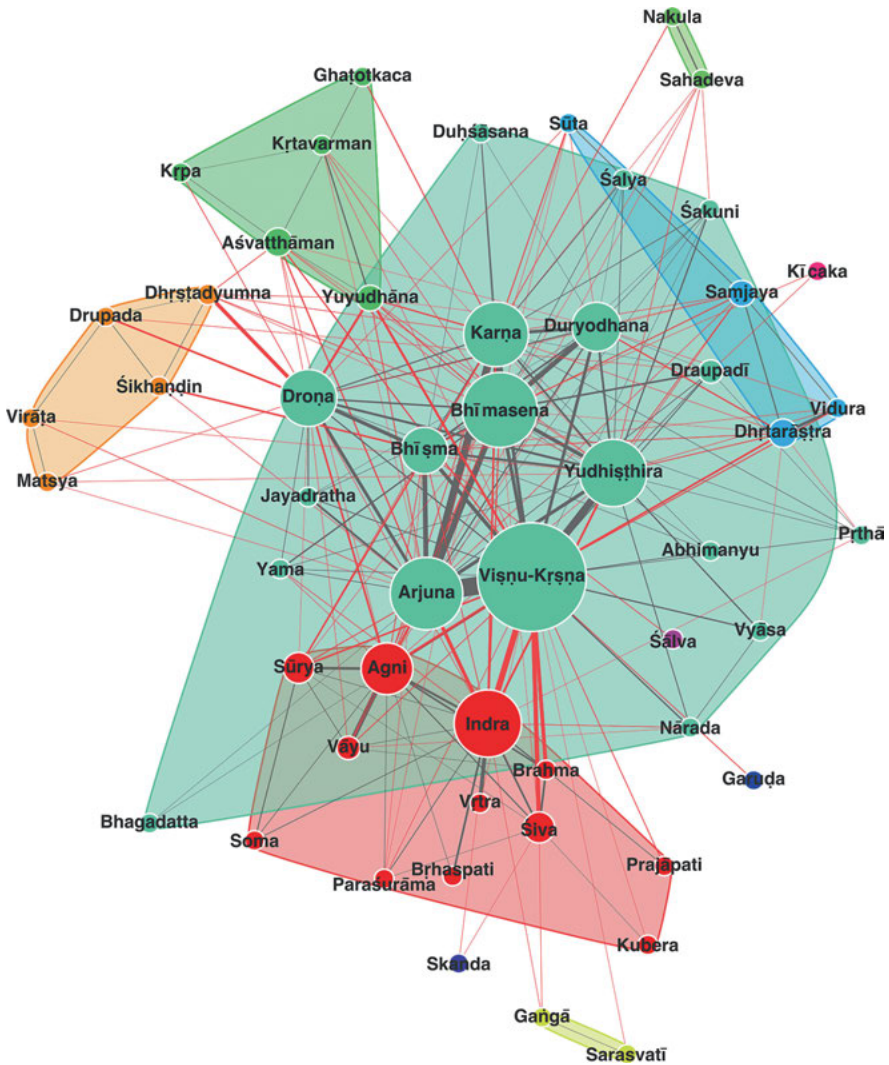

Figure 1: Identifying communities in the Mahābhārata.

This information stemmed from the structural patterns of relations alone. What was missing from this was any information about the kind of relations the actors have. Were they allies or enemies? Were they friends or family?

Which kinds of relationship existed between the gods and the humans? One approach would be to define a limited set of such relation types, as Nagel[26] did in his work. Promising implementations exist that allow us to train a computer to identify these relations from texts, basically training them using a set of examples like one would train a human coder.[27] We chose a different strategy: We did not want to impose our own categories on the material. Instead, we wanted to inductively identify which different connotations personal relations had in the Sanskrit text itself. An algorithm based on topic modeling[28] allowed us to do exactly that: By taking the text that surrounded the mentioning of a pair of persons into account, the computer identified sets of words that are indicative of the relation qualities.[29] Additionally, it identified similar sets of words for the individual actors, allowing to characterize their role in the story. These word lists or "topics" still require interpretation and are less clear-cut than pre-defined categories. But one can argue they are more grounded in the textual data themselves. And they turned out to be quite nuanced: We identified two relation topics that comprised battle-related words. We could not really tell their semantic difference until we added that information to the network and looked at who was connected by those topics. It turned out that one connected primarily the allies who fought side by side in the battles, while the other connected the enemies who fought against each other.

Socio-Semantic Networks of Egyptian Pyramid Texts

For the Ancient Egyptian texts, we chose a different strategy: Here, we included the semantic aspect in the network as nodes, not as edge types. This allowed us to see the structural position of certain concepts in the fabric of the network. We implemented an algorithm for text network analysis that takes a complete text

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26 "Analysing Change in International Politics."

27 Andre Blessing, Jens Stegmann, and Jonas Kuhn, "SOA Meets Relation Extraction: Less May Be More in Interaction," in *Service-Oriented Architectures (SOAs) for the Humanities: Solutions and Impacts*, 2012, 6–11.

28 For an introduction to topic modeling, see Megan R. Brett, "Topic Modeling: A Basic Introduction," *Journal of Digital Humanities* 2, no. 1 (2012), http://journalofdigitalhumanities.org/2-1/topic-modeling-a-basic-introduction-by-megan-r-brett/.

29 Jonathan Chang, Jordan Boyd-Graber, and David M. Blei, "Connections Between the Lines: Augmenting Social Networks with Text," in *Proceedings of the 15th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* (ACM, 2009), 169–78, http://dl.acm.org/citation.cfm?id=1557044.
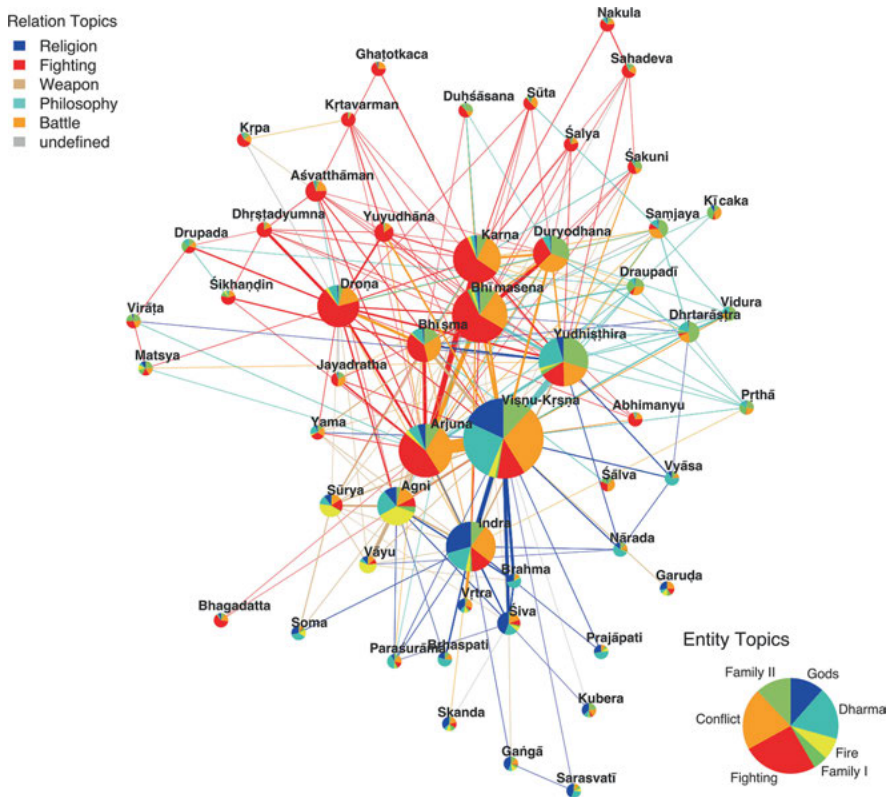
Figure 2: A topic model of network relations in the Mahābhārata.

and represents the co-occurrences of the individual words as a network.[30] This is a completely different kind of network than the one before: It is not a social network, enhanced with semantic information about actors (nodes) and relations (edges), but it is a semantic network that represents the text itself as a web of words[31]. Personal names can also be part of the network, but they are not necessarily privileged over other words.

In our application, we found that this type of network representing a whole text quickly becomes unreadable as the texts (or text corpora) get larger. Thus,

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30 Dmitry Paranyushkin, "Identifying the Pathways for Meaning Circulation Using Text Network Analysis" (Nodus Labs, 2011), http://noduslabs.com/research/pathways-meaning-circulation-text-network-analysis/.

31 Or as a "textexture," to quote the website that first made the algorithm popular: http://textexture.com/.

we adapted the methodology to focus on the context analysis of individual words. Building upon ideas from computational linguistics, we assumed that the different contexts a word is used in and with that its different facets become visible when we map other words used in its vicinity. In a case study, we studied the use of the name of the god Horus in the pyramid texts. We took all nouns which appear in any sentence that mentions Horus and created a text network based on this sample. This shows how Horus is contextualized in the hieroglyphic inscriptions. Running a community detection algorithm on the network gives a hint about different contextual domains.[32]

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32 In a more complex case study, we concurrently analyzed the usage context of two important terms for Ancient Egyptian cosmology, namely Maat and Heka Beate Hofmann and Frederik Elwert, "Heka und Maat. Netzwerkanalyse als Instrument ägyptologischer Bedeutungsanalyse," in *"Vom Leben umfangen". Ägypten, das Alte Testament und das Gespräch der Religionen. Gedenkschrift für Manfred Görg*, ed. Georg Gafus and Stefan Wimmer, Ägypten und Altes Testament 80 (Münster: Ugarit, 2014), 235–45.

Figure 3: A context network of Horus in the pyramid texts.[33]

Lessons Learned

SeNeReKo started in 2012 and ended in 2015. In hindsight, it was a valuable experience and for many of us the first serious endeavor in DH. Saying that we learned a lot during these three years also hints at what we did not know or expect when we envisioned the project. In the end, the project was a test bed for experimenting with different methodologies in text network analysis. But as the focus shifted to basic methodological research, we also somewhat lost focus on our initial research questions. The search for interreligious contact in the sources became somewhat secondary. This was also affected by the selection of the corpora we worked with: The Pāli canon, from which we hoped to learn a lot about that question, turned out to be most difficult to work with in terms of linguistic annotations. But also its narrative structure turned out to be less suited for network analysis than we initially had expected. The Mahābhārata on the other hand, which was a very valuable "data donation" we received during the course of the project, resulted in some of the most advanced network analyses, but revealed next to nothing about interreligious contact.

Next to the increased methodological focus, we also learned a lot about what one might deem dry technical matters like data preparation, linguistic annotation, and interoperability. Only because the texts were already available in digital form and did not have to be scanned or OCR'd did not mean they were ready to be processed. Developing a part of speech tagger for Pāli would probably have been a reasonable research project on its own. But also in cases where we had extensive and rigorous annotations, as in the case of the Egyptian texts, transforming the TLA database structure into something we could run our algorithms on turned out to be a major share of our work.

But even these difficulties were fruitful in the end. Being part of a working group that designed a TEI XML based exchange format for Egyptological projects did not contribute much to our initial research goals, but it feels like probably one of the lasting and valuable contributions to the broader field. The experiences we made during the project now fundamentally shape how we approach new

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33 English translations are used for easier comprehension. The actual analysis was performed on the transliterated text in its original language.

research projects and how we think about open research data and interoperability in general.[34]

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