Networks and religious transformations

1. Introduction

This chapter demonstrates the potential of formal network analysis for the study of religious transformations in past societies. We first clarify the most common types of network structures observed in studying religion. Drawing upon this differentiation, we introduce three levels of analysis for studying religious transformations on varying scales.

2. Religion within spatial, social and textual networks

Generally speaking, spatial networks are comprised of nodes and edges embedded in space, which is assumed to have an effect on the topological properties of these networks (Barthélemy 2011). With respect to past religions, nodes commonly represent settlement sites somehow associated with a religious tradition (e.g. a city with documented presence of a given religion) or locations of objects somehow associated with the tradition (e.g. a temple or inscription mentioning a deity). Since the flow of past religious interactions is often inaccessible to direct measurement, edges and their attributes are typically not specifically religious traits but might simply represent distances to *n* nearest neighbours or routes on a transportation network. In archaeology, spatial networks probably represent the most common form of network analysis of religion (cf. Woolf 2016) with a prominent example represented by the work of Anna Collar (2013), who applied network analysis (especially proximal point analysis; see chapter 10 in this volume) to understand the transmission of ancient Mediterranean traditions such as the cult of Jupiter Dolichenus, the cult of Theos Hypsistos, and the Jewish Diaspora.

The second relevant type of network for analysing religious transformations are social networks, where nodes represent human actors and edges their relationships. Here we mean social networks in a narrow sense, i.e. networks formed by socially interacting human individuals. We maintain that it is useful to strictly differentiate between social networks in this narrow sense and spatial networks, despite the fact that in many cases we study spatial networks just because we attempt to get insights into actual social networks. It is especially the case in the study of past religious phenomena, where the spatial distribution of certain types of sites or objects is often the only information accessible for quantitative operationalisation. However, this does not justify merging these two types of networks into one.

The last type of network discussed here are textual networks, by which we mean mainly word co-occurrence networks (Mihalcea and Radev 2011, pp. 78–80). In these networks, nodes represent particular words, typically in their dictionary form, and edges represent co-occurrences of given words within a certain unit of a larger text or corpus. The unit might be defined either as a sentence or the immediate neighbourhood within the text. The weight of the edges is then the number of co-occurrences of the same two words within the text. This approach draws upon a general assumption from distributional semantics that there exists a correspondence between how people understand certain words and how they use these words in the speeches and texts they produce (Lenci 2018). It has been suggested that distributional semantics models might be a good predictor for people's word-association networks (Galea and Bruza 2015). With respect to the study of religious transformations, these methods might be used to analyse changes in the meaning of certain words from one

text to another. Adopting these methods, we can either analyse textual networks derived from religious texts or to study the usage of religion-related words in texts which cannot be described as religious per se (e.g. novels, newspapers or social media posts). While the method of word co-occurrence networks is far from being the most common one in the fields of natural language processing and computational linguistics, the fact that it can draw upon a broad palette of standardised measurements developed formerly for analysing other types of networks makes it worthy of exploration (Czachesz 2016).

This overview of three types of network structures is not meant to be exhaustive. However, here we focus on these three, since they enable us to capture a wide spectrum of phenomena generally associated with religion: from mental contents as studied by psychologists and cognitive scientists, to spatial patterns commonly explored in archaeology. This broad range of phenomena might also be theoretically stimulating for debates on the very nature of religion. For instance, analysing textual networks can help us to become more sensitive in employing general categories such as "Christian god" or "pagan sacrifice", realizing how the usage of terms related with these concepts evolves from one author to another, even within one religious tradition.

Analogically, the network approach might also have some implications for our understanding of religion in terms of social networks: where does a religious community start and end, who to include and who not, etc.? In case of some cultural contexts, instead of focusing on social networks consisting exclusively of adherents to one particular religious tradition, it might be more fruitful to look at how different individuals are embedded within broader social networks of their city, class, and occupation (cf. Brughmans et al. 2019, p. 3–4) and then to ask how this changes over time with respect to the religious practices these individuals are involved in (cf. Lofland and Stark 1965). We should not ignore the fact that someone's association with a religious tradition rarely is a binary question, despite the exclusivist proclamations often made by religious authorities. It is exactly this fluidity which might be well captured by an appropriate application of network analysis approaches sketched above.

3. Analysing religious transformations on macro, meso and micro levels

One notable feature of the academic study of religion is a high extent of disagreement concerning the very nature of religion. One possible reason for this situation might be that different scholars approach religion on different levels of analysis (Lang and Kundt 2019). Religions and their transformations are observable on differing spatio-temporal scales, deserving to be studied on different levels of analysis. We suggest that network approaches can help us to identify what is common for all these levels of analysis and, at the same time, be sensitive to what differentiates them.

We identify three general analytical levels: *micro* level, analysing religion on the level of spatially and temporally embedded groups or communities; *meso* level, approaching religion on the level of canonized traditions, like Christianity or Buddhism; and a *macro* level, dealing with religion from a long-term, macrohistorical perspective as a phenomenon of human evolution. We propose that each of these levels of analysis can profit from the three different types of network structures introduced above.

3.1 Micro level

Analysing the social network of a religious group or community and its transformations over time is perhaps the most intuitive level of analysis. This approach has a direct overlap with traditional social network analysis (SNA) (Everton 2018). However, since it is not so common in archaeology, we will deal with it only to a limited extent. A textbook example of SNA using religious communal data is the influential work of Samuel F. Sampson (1968) where he provided a social network dataset based on his ethnographic analysis of social relationships among a group of novices in a New England monastery. Sampson based his network on interviewing each novice concerning sympathies and affections to other novices. For example, one layer of ties between individual novices in Sampson's dataset was defined by their answers to the question of whom they liked most and whom they liked least. Their replies can be encoded in a matrix, and interpreted as an adjacency matrix of a weighted directed network (see Fig. 1). Drawing on his observations of the novices' behaviour during his stay among them and the time of their arrival to the monastery, Sampson divided the novices into four groups—Young Turks, Loyal Opposition, Outcasts and an interstitial group—which creates an embedded partition of the nodes which can be visualized as a corresponding block model. As shown in Figure 1, the positive links are much denser within the groups than between the groups and inversely in the negative links.

Approaching social network data for any religious community, it might be of crucial interest for a researcher to identify such groups or clusters within it. In the case of Sampson's dataset, we already have such groups at our disposal (Batagelj and Mrvar, 2006), produced by the author of the dataset himself, who spent a substantial amount of time within the community. However, this is not always the case, especially in archaeology and history where social networks and their change over time are commonly either constructed or approximated in little detail from historical data.

In the absence of a ground truth for the group definition, this can be computed from the data using either stochastic block-modelling techniques or suitable community detection algorithms (see chapter 25 in this volume). Additionally, in Sampson's case, since the dataset contains the "like" relation resolved in three time points, we can follow the evolution of the network over time. For example, as can be seen in the lower part of Figure 1 we can obtain some insights concerning the development of the predefined groups. We observe that some intra-cluster links of the Loyal Opposition disappear while the inter-cluster connectivity is reinforced. Moreover, the node-level metrics such as betweenness centrality could be used in conjunction with the cluster partitioning to identify nodes that could use their position between the clusters to contribute to stabilizing the network.

[insert Kase-Fig 1 here]

It appears that for a scholar studying religion and its transformations on the level of individual communities, the application of formal network analysis methods is a straightforward option. This scholarship can draw on an extensive body of works and advanced tools associated with standard SNA literature. This seems to be a promising research path, despite the fact that, quite surprisingly, SNA scholars "appear to have little or no interest in exploring the interplay of networks and religion" so far (Everton 2018, p. xviii).

Archaeologists and historians commonly do not possess sufficient amounts of data suitable for analysing historical religious communities by means of formal networks tools. To deal with that, social networks are used rather heuristically and in an abstract way (White 1992; Czachesz 2011), sometimes in combination with computer simulations (Kaše et al.

2018). Alternatively, social networks are approximated from data of a different type (e.g. Collar 2013; Munson et al. 2014). However, these analyses rather pertain to the other two levels of analyses.

3.2 Meso level

Scholars interested in religious history typically do not have direct access to individual religious communities. Accordingly, they also commonly follow a different research interest, approaching religion on a different level, in terms of religious traditions and their dynamics. Without doubt, religious traditions are formed by individual communities, but these communities alone claim that they are part of something bigger, which itself deserves to be analysed. On the one hand, relying on rather general descriptive categories like Christianity or Islam, this level of analysis might suffer by being quite insensitive to internal dynamics of religious systems; on the other hand, it is well justifiable when focusing on spatial dimensions of religion, e.g. dissemination of a religious tradition in terms of diffusion. We will demonstrate this approach by focusing on diffusion dynamics of two religious traditions in the environment of the ancient Mediterranean: the spread of early Christianity through the Roman Empire and the Egyptian cults through the Aegean Sea region a few centuries earlier.

The spread of Christianity throughout the ancient Mediterranean has been the subject of an immense number of studies. However, most studies have been purely qualitative, based on close reading of early Christian literary texts, mainly because of a lack of accessible material evidence. An exception represents the work of Rodney Stark. In his two books (Stark 1997, 2006), Stark introduced a series of hypotheses concerning the spread of Christianity throughout the ancient Mediterranean. Two of his hypotheses deserve to be mentioned verbatim: (a) "*The closer a city was to Jerusalem, the sooner a city had a Christian congregation*" (2006, p. 77). (b) "*Larger cities had Christian congregations sooner than smaller cities*" (2006, p. 81). Stark tested these hypotheses relying on a dataset of the 31 biggest cities of the Roman Empire, by employing a rank-order correlation between the date of first appearance of Christianity in these cities against their geographical distance from Jerusalem or their estimated population size.

In one of our studies (Fousek et al. 2018) we empirically re-assessed Stark's original hypotheses in terms of diffusion on a spatial network while employing a more extensive dataset. To calculate distance from Jerusalem, we employed a virtual transportation network model for the Roman Empire *ORBIS* (Scheidel et al. 2012, see also chapter 12 in this volume), which consists of cities, roads, rivers and sea routes as edges and enables a calculation of distance, time duration, and financial expense of travel between 649 cities within the network. Using this data, we operationalised the distance as a *cost of travel* within the transportation network model, which allowed us to incorporate both sea and land travel in a consistent fashion.

Concerning the presence of Christianity in the cities, we geocoded three historical maps depicting places with documented Christian presence before the year 100, 200, and 304 (Van der Meer and Mohrmann 1958). As a result, we obtained a network graph in which each node represents a city and has two important attributes: (1) population size estimate and (2) a date before it settled a Christian congregation (either 100, 200 or 304). The edges represent a simplified version of routes from the transportation network, where the weight attribute is cost of travel. This dataset was then employed to assess Stark's hypotheses.

We first built a gravity model to assess the amount of interaction between two cities within a network (Anderson 2011, see also chapter 11 in this volume) in which the distance

variable was substituted by the cost of travel. Using Spearman rank-order correlation, we found a statistically significant relationship between the first documented presence of Christianity and (a) its distance (respectively the cost of travel) from Jerusalem, (b) its population size and (c) a combination of the two factors. We further built a network model based on effective distance (Iannelli et al. 2017). The effective distance model transforms the diffusion process on a network into a homogenous travelling wave, which allows us to capture the diffusion dynamics without constructing and running an iterative computational model. As a result, we obtained a tree with a source node in Jerusalem representing the most probable paths of the spread of the process, which could be evaluated statistically against the documented presence of Christianity (see Figure 2). This method was especially useful in being able to capture the role of big cities like Rome and Alexandria. However, we also note that it performed significantly worse when modelling the data from the later period, where the factor of distance was probably much less important than in the earlier period.

[**insert Kase-Fig 2 here**]

Our network model of the spread of Christianity took into consideration only spatial and demographic factors, while possible cultural forces were ignored. This does not imply that these factors cannot be involved in such an approach. To demonstrate this possibility, we introduce a second example, a study concerned the spread of Egyptian cults through the ancient Mediterranean a couple of centuries before Christianity.

It is well documented that under the rule of the Ptolemaic dynasty, Egyptian cults began to spread outside Egypt to ports and coastal areas of the ancient Mediterranean (Bricault 2004). One of the recent and influential voices in the lengthy debate, Laurent Bricault, argues that the spread of these cults was influenced mainly by four factors which were not mutually exclusive – commercial, economic, political, and social (Bricault 2004). In another study produced by our team (Glomb et al. 2018), we decided to explore the role of these factors, while conceptualizing this phenomenon as a long-term transmission of specific cultic practice from one socio-spatial milieu to another happening on a transportation network. We were interested in whether we can reveal the spatial correlations between the archaeological evidence related to the Egyptian cults and other proxies, related to political, commercial or general strategic factors, to determine which of these factors promoted the spread of these cults across the Hellenistic Aegean Sea with more significant impact than others.

Because the ORBIS transportation network model introduced above is too coarse for specific regions such as the Aegean Sea, we constructed our own transportation network for this study based on the interpretation and geocoding of the local maritime routes described in the ancient *peripli* collected by Pascal Arnaud (2005).The local presence of the Egyptian cults on the transportation network in the Aegean Sea was based on the spatial distribution of the archaeological evidence from the 3rd and 2nd century BCE (collected in Bricault 2005). We then geocoded a database of Ptolemaic garrisons in the Aegean Sea collected by Bagnall (1976) as a suitable proxy for the local Ptolemaic political presence (see Figure 3).

Finally, to approximate Egyptian commercial activities in the region, we had to identify potential markets for imported Egyptian grain, because Hellenistic Egypt was one of its main exporters. To achieve this, we constructed a mathematical model which based on environmental and demographic datasets estimated whether an island in the Aegean Sea could have suffered from potential food shortages and could therefore have been in need of grain imports and thus in more intensive contact with Egyptian merchants (for details, see Glomb et al. 2018).

An additional variable represented the approximate traffic intensity of Egyptian ships in each port and therefore its potential importance for the process of the spread. Because the spread was directional, the point of origin being Egypt, a simple deterministic agent-based model was constructed to a) send agents from Egypt (Egyptian ships) to each port on the network using the shortest network paths (in km), and b) count how many times each node was visited by an Egyptian ship travelling elsewhere on the network.

The aim of the study was to explore the spatial relationships between the selected factors of potential influence and the distribution of the Egyptian cults; the quality of these relationships was defined by the geographical distance on the transportation network, i.e. if a city had both an Egyptian temple and a Ptolemaic garrison in its proximity on the network, then the relationship between the religious and political proxy is strong/positive and vice versa. To pursue this goal, the shortest paths on the network routes between each pair of nodes were calculated. To evaluate the role of selected factors both individually and cumulatively, we fitted two variants of a generalised linear model (GLM). The model focused on explaining the variability in the response variable (intensity of the Egyptian cults as measured by proximity in km to temples and artefacts) by the impact of three predictors - political influence, famine vulnerability and strategically advantageous position. The results produced by the models suggest that the spreading dynamics of the Egyptian cults in the Aegean Sea region was a multifactorial process with the political factor as the most influential one, and the famine vulnerability with traffic intensity contributed with a lower impact.

[**insert Kase-Fig 3 here**]

This second example clearly indicates that to focus on spatial and demographic constraints is not always sufficient to understand general patterns behind spatial dissemination of religious traditions. However, it also demonstrates that a study originally operationalizing the phenomenon as a network diffusion process might be easily elaborated further and extended to evaluate the role of a large number of other predictors by means of a generalized linear regression model.

3.3 Macro level

Religious traditions are not timeless entities; they emerge, flourish or die in dependence on the environment surrounding them. Therefore, it might be useful to look at religion from an even broader perspective, that of human evolution. On this level, religion is viewed as a set of beliefs and practices which are subject to transformations as the population maintaining them faces new challenges with respect to social organization, living standards, etc. There is an ongoing discussion concerning the dynamics of religion over the last 10-12 thousand years, i.e. approximately from the end of the last ice age and the invention of agriculture. For most of human evolution, people lived in small-scale groups, with a majority of day-to-day social interactions and cooperation based on kin ties and repeated encounters. It is puzzling then what motivated people to cooperate in anonymous environments of emerging large-scale societies, with frequent but non-repeated social interactions between strangers (Turchin 2015). From this perspective, the most disputed empirical question is concerned with certain religious innovations supporting the increasing complexity of human societies (Norenzayan et al. 2016).

One research trajectory suggests that a religious innovation in the form of belief in morally-concerned supernatural agents (the so-called Big Gods) could strengthen trust among cooperating strangers, and in this way enhance the functioning of society as a whole. As "communities increase in complexity and size, the gods' powers and moral concern also

become greater" and "by the time we get to state-level societies, Big Gods predominate and religion becomes intensely intertwined with public morality" (Norenzayan 2016, p. 473). Other scholars criticize this approach and instead propose a key role of frequently repeated rituals as a factor in establishing common identities and thus producing more cohesive societies (Whitehouse et al. 2019). Despite the different mechanisms at work, both views focus on particular religious transformations as somehow galvanizing large-scale societies by supporting trust and cooperation among interacting strangers. Network approaches can stimulate this research in at least two ways. First, the transition from cooperation based on kinship and repeated encounters to cooperation involving numerous interactions between anonymous strangers might be analysed in terms of changes in the structure of social networks. Second, some of these innovations can be traced by means of identifying changes in meaning of certain words in historical texts, a process which might be captured by analysing textual networks.

In terms of social networks, due to some religious innovations, "People may trust in, cooperate with and inter-act fairly within wider social circles, partly because they believe that knowing gods will punish them if they do not" (Purzycki et al. 2016, p. 327). In terms of network analysis, it would be illuminating to explore whether a social network of individuals believing in Big Gods or participating in frequently repeated collective rituals will on average have a higher degree than members of a social network of individuals missing this belief or not participating in this sort of practices. Alternatively, we can hypothesize that the shared belief in morally charged Gods creates additional weak ties in the social network, well-suited to support the trust layer of the network.

There are a couple of studies approaching this sort of hypothesis by means of formal network analysis, mainly by drawing on data from contemporary societies. Eleanor Power (2019) analysed social support networks in two contemporary villages in rural South India. The social support network data resulted from a survey conducted with adult residents of the villages who were asked to free-list those individuals who had provided them some sort of social support during the period of last few months. Power was especially interested in the relationship between individuals' involvement in publicly observable religious practices and their position within the social support network. She hypothesized that since some forms of religious actions are widely observed by other villagers, they might be "potentially used as signals of a person's character and commitment, influencing how others react to and relate with that individual" (Power 2019, p. 2). Employing exponential random graph models (ERGMs), she found that people are more likely to go to a person for support if that person worships regularly or undertakes greater and costlier public religious acts. In contrast, people are less likely to go to someone for support if that person becomes possessed.

Power's approach is explicitly based on signalling theory of religion (Bulbulia and Sosis 2011; Henrich 2009). According to this theory, costly religious acts might serve as reliable signals of commitment and trustworthiness exchanged among members of a society. Because commitment and trustworthiness have certain effects on cooperation within the society, involvement of costly practices might have cultural evolutionary implications for survival fitness of a given society.

Jessica Munson and her colleagues used a very similar theoretical framework while turning their attention to evidence for bloodletting rituals recorded in Classic Maya hieroglyphic texts. Munson and colleagues noticed that previous research on cultural evolution of costly rituals was commonly based on analysing synchronic data from contemporary religious populations and therefore could not sufficiently address how such rituals varied over time or spread between different social groups in the past (Munson et al. 2014, p. 2). To overcome this limitation, they used the Maya Hieroglyphic Database to identify all instances of the ZYC grapheme, a term which has been deciphered as *ch'ahb'* and

semantically closely related with self-sacrifice and bloodletting. They identified 72 sites in the southern Maya region where hieroglyphic monuments were produced during the Classic period from 278 to 889 CE. Within these sites, the authors identified 69 monuments containing the *ch'ahb'* glyph in a context directly associated with bloodletting.

To explain the spatio-temporal distribution of these bloodletting statements, Munson and colleagues constructed a formal network of sites with ties based upon the appearance of foreign emblem glyphs and toponyms in hieroglyphic statements describing specific types of sociopolitical relations (e.g. antagonistic, diplomatic etc.) between Maya polities associated with respective sites (Munson and Macri 2009). First, employing a generalized linear mixed model, the authors found that the occurrence of *ch'ahb'* bloodletting records is best predicted by antagonistic statements. Second, using QAP correlation, the authors identified homophily in the dataset, pointing out to the fact that sites that record bloodletting statements also exhibit a strong tendency to have ties with like others (Munson et al. 2014, p. 9). The association of bloodletting and antagonistic statements about warfare and conflict is consistent with the costly signalling theory of religion, since an elimination of free-riders needs to be addressed especially in a context of potential conflict or warfare. However, we should not overlook that in this case the effect of religion on social networks is studied rather indirectly as approximated by a network of sites.

As already suggested, under certain circumstances, religious transformations on the macro level might also be fruitfully studied by means of textual networks. There is a common view that a crucial step in the development of Big Gods was an appearance of the so-called world religions: "By the start of the Common Era (CE), universalizing religions with powerful moralizing gods (or cosmic forces), universal ethical codes, and contingent afterlife beliefs had emerged across the Old World" (Schulz et al. 2019, p. 1). From this perspective, it has been proposed that Christianity "introduce[d] a stronger moralizing component than previous local religions, as well as the adoption of supernatural beings overtly concerned with morality, which were largely absent in earlier ideologies" (Mullins et al. 2018, p. 615). But was it really the case? One option how to answer this question is to analyse changes in the meaning of the concept of god as captured by word co-occurrence networks.

To explore this question, we generated word co-occurrence networks for each text from 687 texts in a corpus of "Lemmatized Ancient Greek Texts", dated to the period from 8 BCE to 4 CE (Kaše 2020). Including both pagan and Christian texts and covering a time span longer than one millennium, this dataset allows us to obtain valuable insights concerning cultural evolution of religion in the whole ancient Mediterranean region. For each of the networks, we generated a subnetwork consisting from 30 nearest neighbours surrounding the Greek term *θεός* (god) in these networks. This allowed us to inspect how the understanding of god changed from document to document, from author to author, and, especially, how it evolved from one time period to another (see Figure 4). Using an automatic translation of a standardised list of morally loaded words (Graham et al. 2009), it was possible to measure changes in the strength of association between the Greek term *θεός* and the domain of morality. This analysis clearly indicates a substantial increase in this association during the period from 8 BCE to 4 BCE. It is especially remarkable that the association strength between a representation of god and morality in texts from 4 BCE is even higher than in early Christian texts which started to appear approximately 400 years later. This challenges the popular opinion expressed above, seeing the higher association between the concept of god and morality in connection with the emergence of so-called world religions.

[**insert Kase-Fig 4 here**]

Taken together, it should be clear that formal network analysis has a lot of potential

for analysing religion and religious transformations on the macro level, from the perspective of human evolution. In that respect, we envision that network approaches can represent a crucial theoretical and methodological framework for bridging the gap between the rather traditional historical study of religion and recent naturalistic approaches to religion anchored in life sciences (Lang and Kundt 2019).

4. Conclusion

In this chapter, we introduced a series of examples on using network analysis to study religious transformations in past societies. Using these examples with a focus on different levels of analysis respecting the scale of the research problem (micro, meso and macro), we aimed to demonstrate which specific formal network analysis methods are most fruitful to employ with regard to specific network ontologies (spatial, social and textual).

Spatial networks are probably the most common in archaeology and often might be constructed from the data in a straightforward manner. However, since the study of religion is concerned with human thought and behaviour, in proceeding further we also introduced social and textual networks. Considering these two other types of networks is especially meaningful when we attempt to capture not only the external dynamics of a religious tradition (e.g. its spread to new areas), but also the internal one (i.e. changes in social networks or meanings of concepts). The fact that the studied environment does not offer enough data to make these models rigorously empirically testable should not lead us to give up building them completely, since these models still possess important heuristic value (Brughmans et al. 2019). We conclude that the formal network approach to the topic of religious transformation is in its pioneering stages and has significant potential for research problems along the whole spectrum of the academic debate, from those related to individuals in groups to those related to human evolution.

List of Figures

Kase Figure 1: Block model of the Sampson's monastery dataset based on manual labelling showing dense intra-group positive relations (top left) and dense inter-group negative relations (top centre). Similar labelling can be computed Louvain algorithm applied to the positive relation network (top right). Repeating the cluster analysis using time-resolved data reveals the evolution of the social structure (bottom).

Kase Figure 2: Effective distance tree model of Christianization of the Roman Empire in a geographical (left) and abstract (right) visualization. The dots represent cities; the color indicates historically attested presence of Christian community within the city.

Kase Figure 3: Visualisation of all the potential factors of influence in the process of the spread of the Egyptian cults on the transportation network in the Aegean Sea.

Kase Figure 4: Nearest neighbours of the term θεός in word co-occurrence networks based on the Iliad (left) and the Gospel of Matthew (right).

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