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Bridging Historical, Archaeological and Criminal Networks

COLLECTION:
A BRIDGE TOO FAR

EDITORIAL

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1 NETWORK PERSPECTIVES IN HISTORY, ARCHAEOLOGY AND CULTURAL HERITAGE

In recent decades, historians and archaeologists have gradually recognized that network science provides valuable conceptual, theoretical, and computational tools for investigating historical events and gaining deeper insights into the connections between the subjects under investigation. In their studies, they have examined different sources and datasets from various network perspectives, and applied a variety of analytical methods and concepts to study historically and archaeologically informed networks data (for overviews, see e.g. Ahnert et al. 2020: 43–51; Brughmans 2013; Brughmans & Peeples 2018; Collar, Coward & Brughmans 2015; Crabtree & Borck 2019; Knappett 2013; Knappett 2020; Marx 2016; Peeples 2019; Rollinger 2020).

As explained by Ahnert et al. (2020: 5), 'networks are by definition an abstraction into a system of nodes and edges. Nodes are entities; edges are the relationships between them.' What makes up the nodes and edges is, however, case specific, and networks can be represented in many different ways. For instance, the application and implementation of network analysis in archaeology has emphasized the structural representation of relationships between objects, people, and places, guiding recent discoveries on land use, ancient demography, past economies, etc. (Brughmans 2013; Brughmans 2021; Graham 2006; Verhagen, Nuninger & Groenhuijzen 2019). More specifically, archaeologists and historians have employed relational thinking and network analytical methods to study trade routes, production and consumption patterns, communication networks, social and interpersonal networks, group behavior, (social) mobility, diffusion of ideas and technologies, and many other complex phenomena (Brughmans 2021; Cline & Cline 2015; Verhagen 2018).

The application of network science is little explored in relation to art-related crimes, when compared to other forms of illicit trafficking (Costa 2021; Tsai et al. 2019; Vivrette 2022). Yet, network science can also be successfully employed to analyze criminal networks as pertaining to illicit trafficking of cultural heritage both at the national and international scale (Brodie et al. 2022; Graham et al. 2023; Tsirogiannis & Tsirogiannis 2016). Network analysis can, in fact, highlight hidden connections among actors involved in the art trade at different levels, and suggest potential weaknesses within the criminal chains. As such, a distinct network approach can not only serve to bridge disciplines, but also to link the past and the present.

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With this special collection—which continues the discussion initiated during a session organized by the editors at the *Computer Applications and Quantitative Methods in Archaeology* (CAA) conference held in Amsterdam in April 2023[1]—we strive to bridge the gap between archaeological, historical, and criminal network research. To this end, we present a diverse selection of papers and case studies demonstrating ways in which a network perspective can help us better understand past and contemporary systems and datasets. Before introducing the papers, a few words on the many options available to the network analyst are appropriate.

2 A MYRIAD OF TOOLS AND CONCEPTS

Network science offers a plethora of conceptual and digital tools for measuring and exploring network models, of which archaeologists, historians and digital humanists have found aspects of Social Network Analysis (SNA) particularly useful (for introductions to SNA in history and archaeology, see e.g. Collar et al. 2015; Graham, Milligan & Weingart 2016: 195–234. For handbooks, e.g. Borgatti, Everett & Johnson 2013; Scott 2017; Wasserman & Faust 1994). Even within the subfield of SNA, a range of theories, methods and software packages are available for the researcher, offering tools for exploratory as well as descriptive analysis. While they allow the researcher to do nearly anything, it can prove difficult to identify a meaningful (set of) tool(s) and software for the project at hand.

For analyzing small networks, scholars might find that relatively simple solutions like the *Microsoft Excel* extension *NodeXL* will suffice, but open source and user-friendly network analytical software like *Gephi* or *Visone* quickly became popular in historical and archaeological network studies. For handling larger datasets or conducting more complex statistical or network analysis, *UCINET*, *Pajek*, *R* or *Python* might be more appropriate, but because they require the researcher to engage more directly in the calculations they have steeper learning-curves. For visualizing and analyzing networks that are dynamic, multivariable, longue durée or have a particularly strong emphasis on spatial data, yet other applications—like *Nodegoat* or *the Vistorian*—might prove most useful. Often, the network researcher will, however, find that the most fruitful approach is engaging a combination of software, or forming interdisciplinary research teams (Verhagen, Nuninger & Groenhuijzen 2019: 237–238).

The contributions of this special collection similarly make use of various software for the purpose of data processing and network analysis, including *Gephi* (Giovanelli & Traviglia; Santos & Casimiro), *UCINET* (Stefan & Schubert), *R* (Gheorghiade & Spencer; Moreno-Navarro), *Python* (Giovanelli & Traviglia), *Voyant Tools* (Huffer), and *ArcGIS Network Analyst* (Simelius). Moreover, they exercise mixed-method approaches requiring tailored combinations of software, metrics, and perspectives. Identifying such fruitful combinations of tools and concepts is, however, not straightforward. In addition to the wealth of available network analytical theories and methods, matters are complicated by each software offering a range of possibilities for filtering, measuring and visualizing network data. Furthermore, far from all theories and methods are appropriate for studying all types of networks or questions.

As it has often been stressed, nearly anything can be conceptualized as a network and no network analytical study is the same (recently, e.g. Brughmans & Peeples 2023: 1; Kerchbaumer et al. 2020: 2). Consequently, there is still little consensus on how (and which) aspects of network science (of which SNA is but *one* subfield) can be meaningfully applied in history and archaeology (Brughmans, Collar & Coward 2016: 4, 6–7; Kerschbaumer et al. 2020: 1). In every case and with each application, the relevance of available measures and tools will depend on the researchers' topic, objectives, source material, dataset, financial means, technical skills, etc.—all of which may be decisive factors for choosing one's software and methodology (Graham, Milligan & Weingart 2016: 237–240). The ability to assess, pick, and refine network modeling techniques are thus paramount for a correct and scientific reconstruction of past interactions (Birch & Hart 2021; Carreras, De Soto & Munoz 2019; Verhagen, Nuninger & Groenhuijzen 2019), as are handling uncertainties in the network data and critically interpreting the results (Brughmans & Peeples 2023: esp. Ch. 5).

3 HISTORICAL, ARCHAEOLOGICAL AND CRIMINAL NETWORK RESEARCH

Archaeologists and historians tend to work with different source materials and ask different questions, so they will not necessarily see network science through the same lenses, interrogate similar networks, or use the same measures and computational tools in the process (cf. Brughmans, Collar & Coward 2016; Brughmans & Peeples 2023; Düring et al. 2016; Kerschbaumer et al. 2020). Despite significant overlaps, it is therefore not surprising that the subfields of historical network research and archaeological network analysis have developed in different directions. For example, historians more frequently model direct person-to-person relationships, explore communication or social networks and identify and study central figures in them, while archaeologists tend to place a larger emphasis on spatial data and compatibility with Geographic Information Systems (GIS), Least-Cost Path (LCP) analysis, Agent-Based Modeling (ABM), and other types of modeling (Bevan & Wilson

2013; Carreras, de Soto & Munoz 2019; Groenhuijzen & Verhagen 2016; Lewis 2021; Verhagen 2018; Verhagen, Nuninger & Groenhuijzen 2019: 233ff.).

Working with various types of sources, including historical documents and maps, Stefan and Schubert's contribution to this special collection investigates brokerage between the Levant, Black Sea region and Central Europe. The authors examine how changes to the Levantine transit trade impacted 15th–16th century CE Wallachia, Transylvania, and Moldova. In modeling and analyzing trading routes as a directed network, they use formal methods of SNA to study its structure and evaluate the network positions and strategic role(s) of specific cities in it, but also check whether their findings align with the written sources.

Also concerned with ancient trade, but focusing more on how trade networks materialize in local consumption patterns, Moreno-Navarro's paper approaches nine Roman non-elite rural communities with network scientific methods. To measure and study the similarity between sites, the author analyzes co-presence networks that are based on the archaeological record with the Brainerd-Robinson similarity metric. Doing so provides new insights into the local integration of trade networks in 1st–3rd centuries CE Iberia.

Ancient mobility is another phenomenon that is commonly explored from a network perspective in archaeology, and that is here attested on various scales. Considering space, temporality, and seasonality, Gheorghiade and Spencer's study concerns networks of interaction, mobility and trade, as they explore potentials for maritime mobility from Crete to the larger east Mediterranean in the Late Bronze Age (LBA). Using GIS functionality, they create a more representative seascape and present a cost-surface model that incorporates seasonal winds as well as archaeological and technological variables.

On a more local scale, Simelius studies health inequality with regards to inhabitants' access to water in Pompeii, Italy, at the time Mount Vesuvius erupted (79 CE). In addition to calculating Gini coefficients reflecting the distance from private dwellings to water sources such as baths and fountains, the author checks how different factors, like population size or vessel capacity, affect the Gini coefficients. Building on the spatial network analysis of Notarian (2023), this paper demonstrates how network studies can provide a baseline for, and be meaningfully complemented by, other approaches.

Also engaging with various types of sources, including maps, documents, newspapers and tombs, Santos and Casimiro employ network analytical theories and methods to discuss movement and visibility networks in the restricted space of a 19th century CE Portuguese cemetery from a diachronic perspective. In an innovative approach, they model the road network and explore how people moved across the funerary landscape, tweaking the betweenness centrality measure to account for restricted entry options and introducing visibility and attraction elements into the network analyses.

Each historical or archaeological network study is unique, yet scholars who routinely employ network analysis to study archaeological and/or historical data share a lot of common ground, striving to increase our knowledge of the past through network approaches. Regardless of differences in source material, methodologies, perspectives, etc., they also face many of the same challenges in the process (Brughmans, Collar & Coward 2016; Ryan & Ahnert 2021: 61f.). The network under scrutiny does, however, not need to be 'ancient' for researchers to face difficulties for example relating to data incompleteness, or to find particular tools problematic or useful. Network science approaches can for instance also provide us with new tools to delve into the structure of criminal networks and assess the illicit origin of antiquities offered on the market. SNA techniques applied to cultural heritage trafficking may focus on the objects exchanged/looted/forged, or on the actors engaged in dealing/looting/forgery. Either way, the clear purpose is analyzing and developing strategies to prevent illicit trading activities.

In their contribution, Giovanelli and Traviglia introduce an innovative semi-automated system that utilizes Natural Language Processing (NLP), Machine Learning (ML), and SNA to build and study a knowledge graph with the main goals of detecting provenance of antiquities and eventually identifying potential instances of illicit trafficking. For this purpose, they model and analyze a bipartite network of artworks and actors, as well as a monopartite network of only actors, with formal network analytical metrics.

Also addressing issues of antiquities dealing and how such trades may result in losses to the archaeological record, Huffer reviews and contextualizes a sales tactic unique to the Australian human remains trade with covert ethnography and grounded theory. To study the loophole, in which human remains are offered as 'gifts' accompanying purchased photographs, he identifies main actors and discourses in selected sales posts and associated comments shared on online platforms with network analysis and a t-distributed Stochastic Neighbor Embedding (t-SNE) plot of the most frequent words.

Such criminal network studies can not only lead to new insights or suggest novel approaches for bringing down criminal systems, but also inspire scholars of neighboring fields by means presenting alternative perspectives and ways to study and think about networks reflecting ancient material and data. In this respect, it is worth remembering that, roughly a decade ago, Lemercier (2012) and Brughmans (2013) reported general unawareness of the history, underlying sociological theories, and diversity of existing social network analytical approaches in history and archaeology respectively. As is reflected by the online

bibliography of the *Historical Network Research* community and events organized by this and other communities, like *The Connected Past*, many new and creative projects have since seen the light of day.[2] Nevertheless, we still have much to learn from one another.

Particularly promising, is that recent publications have also started to critically ask what network analytical results *mean* and how reliable they are, for example by testing for uncertainties and checking the robustness level of formal measures (e.g. Bennett, Tambs & Lindén, Forthcoming: esp. App. D; Brughmans & Peeples 2023: 162–186; Groenhuijzen & Verhagen 2016; Ryan & Ahnert 2021; de Valeriola 2021). Such efforts suggest that we are gradually maturing beyond the fields' formative stages.

In this respect, it is also interesting to note that several of the papers of this special collection test the robustness or otherwise assess the performance of applied tools. For example, Moreno-Navarro checks the robustness of the Brainerd-Robinson results through a bootstrap resampling procedure, Simelius tests how various factors impact calculated Gini coefficients, Santos and Casimiro evaluates how changing the relative strength assigned to the two doors affect their modified betweenness centrality measure, and Giovanelli and Traviglia discuss their models' robustness in entity recognition before evaluating the similarity outputs.

Despite an increasing number of network studies in archaeology and history, Holland-Lulewicz and Thompson (2022: 2) recently reported that 'such applications remain limited to cases employing either solely archaeological evidence or solely documentary evidence'. Moving forwards, we—the editors—believe there is a lot to learn from individual approaches, but also wide possibilities for more interdisciplinary collaboration. As an alternative to reinventing the wheel, we can try looking across disciplinary boundaries to see what network-oriented colleagues in other fields are doing. To assess how network science has assisted others studying phenomena such as mobility and trade (in the distant past or contemporary world), but also gain inspiration from seeing what different software allow us to investigate, or how others have checked the sensitivity level of formal measures in relation to specific data issues. We are sure the readers will agree that this approach allows us to showcase a diverse set of case studies and methodologies that are nevertheless firmly linked by the common denominator that is their network perspectives.

4 CONCLUDING REMARKS

With this work, our intention is not to merge historical, archaeological and criminal network research, or to diminish what qualifies these and related lines of network analysis. Rather, we aim to bridge them by creating new (and strengthening existing) ties of inspiration, knowledge sharing and collaboration between them. Acknowledging that increased dialogue between the named communities and sub-disciplines can help raise awareness of relevant tools, but also spark new ideas, methodologies and collaborations, we organized the CAA session 'A Bridge too Far' and publish this special collection to help facilitate such communications.

Earlier this year, Brughmans and Peeples (2023: 271ff) specified a number of areas of archaeological concern for which relational thinking and network science can make significant contributions. Speaking about past economies and economic integration, they stress that 'a large number of relational theories to explain these phenomena have been developed by archaeologists and historians alike' (Brughmans & Peeples 2023: 277). Moreover, they predicted interpersonal networks to be a key topic of relevance for historians *and* archaeologists moving forwards. We share their notion that these (and other) highlighted topics can be further advanced by cross-disciplinary network research, that take archaeological, historical and/or criminal networks and network data into consideration when available and relevant.

While the connection between historical and archaeological network research might seem more apparent or familiar, criminal network analysis can for example also add to larger discussions on economic systems and human behavior, not least because such research projects may involve human agents that are still alive. A first step towards such cross-disciplinary efforts is, however, to raise awareness of what historians, archaeologists and cultural heritage-oriented scholars are using theories and methods of network science for, and which (combinations of) tools they deem particularly useful (or problematic) for studying various relational phenomena.

Several of the contributions that make up this special collection, and other papers presented during the related CAA session, testify to the fruitfulness of *combining* written and archaeological data and looking *across* disciplinary boundaries when appropriate. By presenting them collectively, we hope to bridge the gap and contribute to the further development of these promising sub-fields of network science.

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NOTES

1. S.32, https://2023.caaconference.org/programme/sessions/ [Last accessed 21 September 2023].
2. https://historicalnetworkresearch.org/bibliography/; https://historicalnetworkresearch.org/hnr-events/; https://connectedpast.net/other-events/ [Last accessed 30 September 2023].

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The authors have no competing interests to declare.

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CITED NETWORK ANALYTICAL SOFTWARE

- ArcGIS Network Analyst (https://www.esri.com/en-us/arcgis/products/arcgis-network-analyst/overview)
- Gephi (https://gephi.org/)
- Nodegoat (https://nodegoat.net/)
- NodeXL (https://www.smrfoundation.org/nodexl/)
- Pajek (http://mrvar.fdv.uni-lj.si/pajek/)
- Python (https://www.python.org/)
- R (https://www.r-project.org/)
- The Vistorian (https://vistorian.net/)
- UCINET (https://sites.google.com/site/ucinetsoftware/home)
- Visone (https://visone.ethz.ch/)
- Voyant Tools (https://voyant-tools.org/)

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