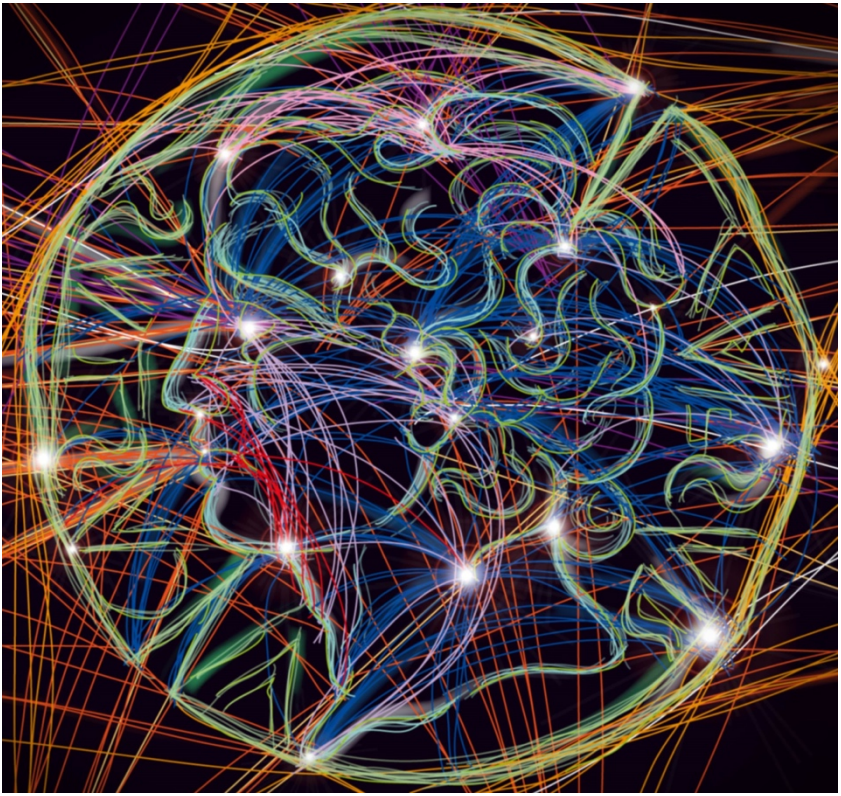

The Connected Past

University of Oxford
6-7 December 2018

#TCPOxford18

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UNIVERSITY OF OXFORD

TORCH
THE OXFORD RESEARCH CENTRE IN THE HUMANITIES
UNIVERSITY OF OXFORD

Programme

Thursday 6 December 2018

08:30-09:00 Coffee and tea

Session 1

09:00-09:20
Social networks, tradition, and innovation in the potters' quarters of ancient Athens. *Diane Harris Cline (George Washington University) and Eleni Hasaki (University of Arizona)*

09:20-09:40
The Network of the Lindian Chronicle: Contrasting Rhodian Networks Real and Imagined. *Gregory J. Callaghan (University of Pennsylvania)*

09:40-10:00
Diachronic Entanglements at Çatalhöyük: Tacit knowledge and data-scaffolding of person-thing networks. *Angus Mol (Leiden University) and Dominik Lukas (Stanford University)*

10:00-10:20
Modelling Networks of Obsidian Production in Northern Ethiopia and of Copper Production in Northern Oman: A Comparative Study. *Ioana A. Dumitru (Johns Hopkins University) and Michael J. Harrower (Johns Hopkins University)*

10:20-10:50 Coffee and tea

Session 2

10:50-11:10
Cities and roads as pattern formation of their co-evolving dynamics on real-world landscape. *Takaaki Aoki (Kagawa University), Naoya Fujiwara (Tohoku University), Mark Fricker (University of Oxford) and Toshiyuki Nakagaki (Hokkaido University)*

11:10-11:30
Percolation robustness and the deep history of regionality. *Mark Lake (University College London), Theo Brown (Helyx Secure Information Systems) and Simon Maddison (Independent Researcher)*

11:30-11:50
Fundamental limitations of past states inference in complex networks. *Jean-Gabriel Young (Université Laval), Laurent Hébert-Dufresne (Université Laval, University of Vermont), Edward Laurence (Université Laval), Charles Murphy (Université Laval), Guillaume St-Onge (Université Laval), Patrick Desrosiers (Université Laval)*

11:50-12:20 Short talks (2 minutes each)

Provincial sculptural networks in the early Roman empire. *Penny Coombe (University of Oxford)*

The Byzantine defensive network of Northern Puglia between X and XI century. *Dino Alberto Rapisarda (University of Florence), Sarah Murgolo (Rheinische Friedrich-Wilhelms-Universität Bonn) and Cosimo Damiano Diella (University of Florence)*

Uncovering Networks within 700 years of material textual culture in the Arabic world. *Thomas Efer (Universität Leipzig)*

Stock Market Networks & Connectivity. Technology transfer between the Toronto Stock Exchange and the Bourse de Paris in the 1980s. *Johanna Gautier (Graduate Institute of International and Development Studies, Geneva)*

Tracing the Transmission of Conceptions of Deity: Epithets of Jupiter in Roman Imperial Italy. *Zehavi Husser (Biola University)*

Using networks to update an unfashionable archaeological concept: the Atlantic Bronze Age as a complex web of different and changing connections. *Juan Latorre-Ruiz (University of Oxford)*

The "Desert Networks" Project: Presentation, Methodology, and Initial Results of a Project on the Physical, Economic and Social Networks of the Eastern Desert of Egypt during Antiquity. *Bérangère Redon (CNRS), Chloé Aussaresses, Alexandre Rabot (University of Lyon)*

Inferring temporal networks based on spatial localization. An application to organic dairy production in the USA: 2002-2015. *Juan Carlos Sanchez Herrera (New York University)*

Mapping Mithraic Cult Iconography using Network Analysis. *Kevin Stoba (University of Liverpool)*

Networks of text reuse in early Chinese literature. *Donald Sturgeon (Harvard University)*

Network of Motifs - Applying Network Analysis on Multi-Sided Aegean Seals. *Martina Trognitz (Universtity of Heidelberg and Austrian Academy of Sciences)*

Mapping Exegesis: Networks of Scholars and Readers in the Carolingian World. *Clare Woods (Duke University)*

12:20-13:10 Lunch; posters displayed

Session 3

13:10-13:30
Dealing with uncertainties, data-biases and long-term perspectives: A

methodological implementation to test Mediterranean Networks and seaborne routes between 8BC-5AD. *Manuela Ritondale (University of Groningen) and Luce Prignano (University of Barcelona)*

13:30-13:50
Harbours and nets in the Levant. *Anja Rutter (Christian-Albrechts-University/Kiel)*

13:50-14:10
Studying the networking system between medieval strongholds (Forts and Fortalices) of Garhwal Himalaya: A case study of Chaundkot fort. *Nagendra Singh Rawat (Hemvati Nandan Bahuguna Garhwal University), Vinod Nautiyal (Hemvati Nandan Bahuguna Garhwal University)*

14:10-14:30
Expanding the interpretation of ancient buried cities. The application of Space Syntax to the Roman town of Falerii Novi (IT). *Fabiana Battistin (Università della Tuscia)*

14:30-14:50 Coffee and tea

Session 4

14:50-15:10
Local exchange or long-distance exchange. A network approach to the late antique Silk Road. *Tomas Larsen Høisæter (The University of Bergen)*

15:10-15:30
Empire in the Backlands: Territorial Expansion and Integration during Colonial Brazil's Mining Boom (1690s-1750s). *Leonardo Barleta (Stanford University)*

15:30-15:50
Relational history: network analysis, oral history and the Nazi camp archipelago. *Alexander Prenninger (Ludwig Boltzmann Institute for History and Society, Vienna)*

15:50-16:10
Stochastic Network Models in Historical Network Research. *Matthias Bixler (University of Zurich) and Martin Stark (ILS Aachen)*

16:10-16:30 Reception

16:30-17:15 Keynote Nathalie Henry Riche
The superpowers of visualization

17:15-17:30 Walk to Trinity College

17:30-19:00 Wine reception in Trinity College beer cellar

Friday 7 December 2018

08:30-09:00 Coffee and tea

09:00-09:45 Keynote Matthew Peeples
The Promise of Large-Scale Data Synthesis for Archaeological Network Research

09:45-10:15 Coffee and tea

Session 5

10:15-10:35
Mapping Literary Cosmopolitanism: Three Methodological Challenges in the Digital Era. *Colton Valentine (University of Oxford)*

10:35-10:55
From Kinship to Scholarship: Changing Patterns of Literati Networking in Song and Yuan China. *Peter K. Bol (Harvard University)*

10:55-11:15
Analysis of material culture: a network-based approach. *Sarah M. Griffin (University of Oxford) and Florian Klimm (University of Oxford)*

11:15-11:35
Creating networks from text with Recogito. *Valeria Vitale (School of Advanced Studies, University of London), Rainer Simon (AIT Austrian Institute of Technology), Elton Barker (The Open University), Leif Isaksen (University of Exeter), Rebecca Kahn (Humboldt Institute for Internet and Society)*

11:35-11:55
Network analysis of late-antique synodical documentation and the reception of the Council of Ephesus (431). *Luise Marion Frenkel (Universidade de São Paulo / St Edmund's College, Cambridge)*

11:55-12:15 Grouped speed dating

12:15-13:00 Lunch; posters displayed

Session 6

13:00-13:20
Recalibrating the Digital Humanities for Archaeology: The Mycenaean Aegean *Paula Gheorghiade (University of Toronto), Henry Price (Imperial College London), Carl Knappett (University of Toronto), Ray Rivers (Imperial College London) and Tim Evans (Imperial College London)*

13:20-13:40
Tracking spatio-temporal social networks in Northern New Zealand: A case

study on the origins of Māori society. *Thegn Ladefoged (University of Auckland), Caleb Gemmell (University of Auckland), Dion O'Neale (University of Auckland), Alex Jorgensen (University of Auckland), Hayley Glover (University of Auckland), Christopher Stevenson (Virginia Commonwealth University) and Mark McCoy (Southern Methodist University)*

13:40-14:00
Cash Crops and Snake Kings: Integrating Archaeology, Epigraphy, and Network Analysis in the Southern Maya Mountains. *Nicholas Carter (Harvard University), Dorothy Carter (University of Georgia), Nathan Carter (University of Georgia), Rachel Opitz (University of Arkansas), and Adam Barnes (University of Arkansas)*

14:00-14:20
MonkBook': Towards an understanding of social networking in medieval monastic orders. *Harriett Webster (University of Wales Trinity Saint David)*

14:20-14:40
Intellectual and Material Networks over the Long Eighteenth Century. *Mark J. Hill (University of Helsinki) and Ville Vaara (University of Helsinki)*

14:40-15:00 Coffee and tea

Session 7

15:00-15:20
Modelling Ptolemaic Pathyris as Nodes and Edges: a Critical Evaluation of Network Methods for Small-Scale Community Studies. *Lena Tambs (University of Cologne)*

15:20-15:40
Female Networks in the Late Roman Republican. *Gregory H. Gilles*

15:40-16:00
Building the Church in the Late Antique West (380-450 CE): a Social Network and New Institutionalist Approach. *David Natal (Royal Holloway)*

16:00-16:20
Connected through the past? Social and geospatial structure and dynamics of networks of socialist Red women during and after the Finnish Civil War in 1918 *Kimmo Elo (University of Helsinki) and Tiina Lintunen (University of Turku)*

16:20-16:40
Re-assembling the social in archaeological network analysis: towards networks of practice. *Lieve Donnellan (VU University Amsterdam)*

16:40-17:10 Reception

17:10-19:00 Discussion panel: human evolution and network science

Abstracts

Keynotes

The superpowers of visualization

Nathalie Henry Riche (Microsoft Research)

In this talk I am going to highlight two superpowers of data visualization. The first one is to help people answer questions about data that they did not even know they had! Representing data visually and interacting with these representations enable raising questions, form hypotheses and gain new insights about it. I will demonstrate this power through several research prototypes for conducting visual data exploration of graphs and networks. The second superpower of visualization is to help people communicate findings in a compelling manner. A picture is worth a thousand words! I will showcase several research prototypes for visual data storytelling. Hopefully, by the end of the talk, everyone will want to leverage these superpowers, and collaborate with researchers to incorporate visualization into their workflow.

The Promise of Large-Scale Data Synthesis for Archaeological Network Research.

Matthew Peeples (Arizona State University)

The rise in popularity of networks in archaeology over the last decade or so has closely followed the rise of numerous collaborative efforts to integrate archaeological data at the scale of regions, continents, or even world-wide. Archaeological data provide the only direct source of information for exploring the structure and dynamics of social systems beyond the historic record and many archaeologists are trying to use this unique position to contribute to ongoing debates in the broader social and behavioral sciences. Not only are we increasingly able to replicate the findings of other social scientists, we are also discovering robust patterns in human societies that transcend the time-scales typically considered in comparative social science research. More data is not necessarily good data (and this should concern us), but I argue that there is considerable promise in such large-scale, empirical, synthetic archaeological research. In this talk, I outline the efforts of the one large collaborative research team (The Southwest Social Networks Project now cyberSW) over the last decade to apply social network methods and models toward questions at the intersection of networks and culture. This research involves the analyses of a massive settlement and material culture database spanning a period of 1,000 years across the U.S. Southwest and Mexican Northwest. Our work suggests that the nature of networks and the risks and rewards associated with network positions are both historically contingent and tied to broader trends in political organizational complexity and demographic scale. Such associations are difficult to uncover within a single regional/cultural context, and thus, such large-scale archaeological network studies have considerable potential for revealing comparative insights both within archaeology and beyond.

Long talks

Cities and roads as pattern formation of their co-evolving dynamics on real-world landscape. *Takaaki Aoki (Kagawa University), Naoya Fujiwara (Tohoku University), Mark Fricker (University of Oxford) and Toshiyuki Nakagaki (Hokkaido University)*

Cities and their inter-connected transport networks form part of the fundamental infrastructure developed by human societies. Their organisation reflects a complex interplay between many natural and social factors, including *inter alia* natural resources, landscape, and climate on the one hand, combined with business, commerce, politics, diplomacy and culture on the other. Nevertheless, despite this complexity, there has been some success in capturing key aspects of city growth and network formation in relatively simple models that include non-linear positive feedback loops. However, these models are typically embedded in an idealised, homogeneous space, leading to regularly-spaced, lattice-like distributions arising from Turing-type pattern formation. Here we argue that the geographical landscape plays a much more dominant, but neglected role in pattern formation. To examine this hypothesis, we evaluate the weighted distance between locations based on a least cost path across the natural terrain, determined from high-resolution digital topographic databases for the Hokkaido region of Japan. These weights are included in a co-evolving, dynamical model of both population aggregation in cities, and movement via an evolving transport network. We compare the results from the stationary state of the system with current population distributions from census data, and show a reasonable fit, both qualitatively and quantitatively, compared with models in homogeneous space. Thus we infer that that addition of weighted topography from the natural landscape to these models is both necessary and almost sufficient to reproduce the majority of the real-world spatial pattern of city sizes and locations in this example.

Empire in the Backlands: Territorial Expansion and Integration during Colonial Brazil's Mining Boom (1690s-1750s). *Leonardo Barleta (Stanford University)*

During the eighteenth century, the Portuguese colonization of Brazil rapidly expanded over the interior of South America after the discovery of wealthy mineral deposits in the continent's backlands. This process challenged traditional forms of spatial organization of a predominantly maritime empire and demanded adaptations in the ways in which administration and colonists dealt with the fragmented, dispersed territorial reality. This paper examines the mechanisms that allowed the formation and, more importantly, the integration of these faraway backlands to the Portuguese empire by investigating social and economic networks that connected distant places. It highlights the formation of two kinds of networks and the changes their spatial composition suffered over time. First, the research addresses kinship networks that were involved in the process of expansion and settling of these remote areas. As the occupation of the interior gained momentum in the eighteenth century, the focus turns to the creation of commercial networks of commission agents, discussing their role of economically linking the backlands to the imperial and global economy. The paper discusses the methodological stakes of dealing with historical spatial networks, highlighting the incomplete and biased nature of the records from the past and the intersection between spatial networks and practices of mobility that shaped colonial Brazil's territory.

Expanding the interpretation of ancient buried cities. The application of Space Syntax to the Roman town of Falerii Novi (IT). *Fabiana Battistin (Università della Tuscia)*

One of the techniques currently applied in archaeology to analyse urban street networks is Space Syntax, developed by Hillier and Hanson in the 1980s. Through the analysis of spatial configurations, it facilitates the formulation of hypotheses about social behaviour. Space Syntax also has proven to be effective in reconstructing and interpreting lost social contexts, given the simplicity of the basic social principles upon which it operates. Numerous case studies working with ancient and contemporary data sets attest to the successful application of its methodologies. This paper presents a new interdisciplinary application of Space Syntax to archaeological material. Street networks of buried cities that have been identified through geophysical prospection are subjected to network analyses. The purpose of this research is to verify whether the technique can be of help in the interpretation or possible reconstruction of incomplete street layouts. The selected case study comes from the Roman city of Falerii Novi (IT), which was founded in the 241 BC and is thought to cover an area of roughly32 hectars. The majority of the city remains completely buried under privately owned agricultural land, excluding the possibility of extensive stratigraphic excavation. In such situations, the application of Space Syntax to unexcavated urban areas can identify areas in which targeted excavation could identify significant features of the urban fabric and for the general understanding of the urban system.

Stochastic Network Models in Historical Network Research. *Matthias Bixler (University of Zurich) and Martin Stark (ILS Aachen)*

A growing number of studies from all historical periods have shown that SNA can be fruitfully applied to selected bodies of historical sources. However, most existing studies are limited to a handful of descriptive structural measures and visualizations of network graphs and despite historical data being inherently longitudinal they are aggregated and analyzed in cross-sectional research designs.

This paper will discuss potentials and limitations of historical data with respect to (longitudinal) stochastic network models. Longitudinal stochastic actor-oriented modeling (SAOM) will be applied to analyze the structural dynamics of a 19thcentury rural credit market. This credit market is modeled as an evolving two-mode social network, where debtors are linked to creditors through economic ties (mortgages). The study is based on archival records of a village in the Kingdom of Wuerttemberg in Southwestern Germany. The period and the region under study follows a significant reformation of the mortgage legislation, by which it was intended to increase transparency regarding the pledging of immovable property. Results show that after the new laws came into effect, the credit market expanded significantly while the market power of single creditors decreased significantly at the same time. In line with previous research on premodern (credit) markets, it can be concluded that the new legislation initiated a transformation of the market from a premodern state to a modern market in a more neo-classical sense of the word.

From Kinship to Scholarship: Changing Patterns of Literati Networking in Song and Yuan China. *Peter K. Bol (Harvard University)*

This study is based on the kinship and literary connections of over 2000 literati from one prefecture in Zhejiang province during China's Southern Song (1127-1279) and Yuan (1279-1368) periods. The dataset is drawn from the China Biographical Database which as of fall 2017 had data on the careers, kinship and social associations of 417,000 men and women. The database can be queried online and can be freely downloaded from the website at https://projects.iq.harvard.edu/cbdb.

The shift, from the eleventh to the twelfth century, in marriage patterns among families of state officials from translocal marriage to local marriage marks what has been called a "localist turn" in China's history. This is amply borne out by evidence from numerous funerary biographies. However, following the Mongol conquest in 1279 the closing of the civil service examination system reduced both career opportunities and one of the principal means of maintaining cohesion among local literati elites. At the same time a new emphasis on the formation of lineages based on common descent from an apical ancestor and the advent of single surname villages oriented families toward relations with immediately proximate lineages rather than other literati per sé. Under these circumstances the local literati elite sought to establish cohesion not by marriage but by building networks through scholarly and literary associations.

The Network of the Lindian Chronicle: Contrasting Rhodian Networks Real and Imagined. *Gregory J. Callaghan (University of Pennsylvania)*

An inscription erected in 100 BCE in the Sanctuary of Athena Lindia on Rhodes records a series of votive offerings lost to the ravages of time. Of these, thirty-two were either dedicated by or evoked a foreign community or individual, with connections ranging across the Mediterranean. It is often held up as a prime example of ancient networks and the connectivity of the Mediterranean World (*e.g.* in Malkin's *A Small Greek World*), but scholarship has largely taken it in stride as a self-explanatory outgrowth of Rhodes' position as a major mercantile hub, and to date no one has fully developed the network and set the results in context.

This paper finally diagrams the network evoked within the inscription. The wonder of the Lindian Chronicle is that, as a lengthy narrative text rather than an amalgamation of disparate bodies of evidence, it presents a discrete and coherent network. This network stretches across the Mediterranean, with a particular emphasis on an East-West axis of connectivity. But it does not reflect a real network—instead, it reflects connections that the chroniclers wished to demonstrate, not that actually existed. If we turn to the archaeological record through the survival of Rhodian trade amphorae, we see that actual Rhodian trade and connections on an East-West route had declined significantly after 146. In this paper, I seek to reconcile these two layers of Rhodian networks—the real and imagined—and to explain why the Rhodians chose to evoke this particular network in the Lindian Chronicle.

Cash Crops and Snake Kings: Integrating Archaeology, Epigraphy, and Network Analysis in the Southern Maya Mountains. *Nicholas Carter (Harvard University), Dorothy Carter (University of Georgia), Nathan Carter (University of Georgia), Rachel Opitz (University of Arkansas), and Adam Barnes (University of Arkansas)*

This paper explores the breakdown of ancient Maya political and economic networks during the eighth and ninth centuries A.D. in the southern Maya Mountains of Guatemala and Belize. Hieroglyphic and material cultural data indicate that sites in this region were integrated into an alliance network centered on the distant, hegemonic kingdom of Calakmul, which exercised power there directly and through intermediates. Over more than a hundred years, that network disintegrated, impinged on by rival kingdoms and pulled apart by internal hostilities. Here, we use longitudinal network analysis and evidence from archaeology, geographic information systems, and epigraphic decipherment to investigate the causes and processes of that disintegration.

Re-assembling the social in archaeological network analysis: towards networks of practice. *Lieve Donnellan (VU University Amsterdam)*

Formal methods for studying connected archaeological data have recently come under scrutiny for their perceived lack of agency, to be situated at the level of human actors as well as material actants (e.g. Van Oyen 2016, 2017). It is believed that imposing a network structure on data puts constraints on the dynamic and situational relations humans and things maintain with each other. As a consequence, all formally defined structures or properties flowing from structures are a-social - speaking from a recent critical social-theoretical perspective.

As a consequence of the broad scales and the very nature of the evidence they are usually investigating, archaeologists often find it difficult to situate agency beyond the structuralist level (e.g. Collar *et al.* 2015; Donnellan 2016 and *forthcoming*). However, as all methods of social enquiry are eventually temporally limited and thus bound in some way and people, objects and ideas follow inevitably different time trajectories, it is theoretically possible to construct a formal framework with analytical value. It is proposed here that including people, objects and contextual constraints within this formal framework enables it to move towards an analysis of situational practice that can be linked to repeated behaviour. Thus, formal methods of network analysis can be used to construct behavioural patterns that can be framed within a valid social-theoretical framework. This paper uses data from a number of protohistoric funerary contexts in Campania (Italy) to outline networks of practice - in practice.

Modelling Networks of Obsidian Production in Northern Ethiopia and of Copper Production in Northern Oman: A Comparative Study. *Ioana A. Dumitru (Johns Hopkins University) and Michael J. Harrower (Johns Hopkins University)*

This paper reports results of comparative research on socioeconomic networks of raw material exploitation, production, and trade. Focusing on obsidian in northern Ethiopia and on copper in northern Oman reveals the long-term development of networks that exploited and traded two different materials in two different contexts, including the pivotal role played by geography and technology. Ethiopian obsidian moved long distances since the Middle Stone Age and was widely traded across the Red Sea region during the Holocene, including during the Pre-Aksumite (1600 – 50 BCE) and Aksumite (50 BCE – 700 CE) periods. Oman was a major ancient source of copper that supplied the Gulf region and Mesopotamia as early as 5000 years ago and became a major supplier of bronze during the Iron Age and Islamic periods.

Our investigations employ archaeological survey, hyperspectral satellite imagery for precision mapping of obsidian and copper resources, x-ray fluorescence of slags, ores, and obsidian samples, GIS for mapping human-environment interactions, and social network analysis for modelling the connectivity of socioeconomic networks. By tracing the development of socioeconomic networks diachronically, we identify aspects of network structures that remained consistent through time due to natural resource availabilities, as well as aspects that changed over time in concert with changing socioeconomic, technological, and culture-historical circumstances.

Connected through the past? Social and geospatial structure and dynamics of networks of socialist Red women during and after the Finnish Civil War in 1918. *Kimmo Elo (University of Helsinki) and Tiina Lintunen (University of Turku)*

Our paper analyses revolutionary people who participated in the Finnish Civil war on the rebellious Red side in 1918. The focus of our analysis lies on the structure and dynamics of the networks of Red women from the district Pori in south-western Finland. Our analysis start by examining connections and networks created by membership in the labour movement, place of residence and kinship in 1918. In the second stage of the analysis we focus on network dynamics and analyse how movings changed the social networks and whether social factors related to the common past could explain network dynamics.

In order to see the layers of the connections both in social and geospatial domain, we utilize historical social network. This allows us to see the significance and impact of regional, social networks and improves our understanding of structural factors affecting the intra-group dynamics among these revolutionary women. The results evidence the exploratory and explanatory power of historical network analysis and its usefulness for gaining new viewpoints on past phenomena.

Our analysis is based on data of 267 women who ended up in court and were charged with committing treason or assisting in treasonous activity. These women were a heterogeneous group and had either worked in service, been agitators, or were Red refugees.

Network analysis of late-antique synodical documentation and the reception of the Council of Ephesus (431). *Luise Marion Frenkel (Universidade de São Paulo / St Edmund's College, Cambridge)*

Concomitant to the rise of the notion of Fathers of the Church and the authority of (some of) their writings in the late fourth and fifth centuries, Christian discourses developed strategies to access information of all periods and places. The relevance of epistolary networks in the literary, pastoral and polemical activities has been shown in a number of case studies, focused on authors such as Theodoret of Cyrrhus, Ambrose of Milan and Leo of Rome and the papyrological evidence of bishops and monasteries in Egypt. Also florilegia and catenae have likewise been explored as instruments to establish networks with past concepts. The availability of documents and existence of archives, often designated in geographical or institutional terms, has generally been taken for granted, but is increasingly contested. This paper will analyse the credibility of written and oral information that allowed the collection of narratives about Christian synods, considering in spatial networks also the influence of the letter-bearers. It will show the 'private' character of the collections, organised as hermeneutical and exegetical tools, discussing the ranked distances of the

spatial networks of their polemical and pastoral use, using the texts about the proceedings of the Council of Ephesus in 431 in Greek, Coptic and Syriac as a case-study.

Recalibrating the Digital Humanities for Archaeology: The Mycenaean Aegean.
Paula Gheorghiade (University of Toronto), Henry Price (Imperial College London), Carl Knappett (University of Toronto), Ray Rivers (Imperial College London) and Tim Evans (Imperial College London)

The 'big data' whose analysis constitutes the paradigm of the 'Digital Humanities' are not, in general, present in archaeology. Rather, instead of 'big data' we have the very different 'lots of data', exemplified by a wide range of ceramic evidence, used in reconstructing function and dating of archaeological spaces. Although this data cannot, in most cases, be taken as a representative sample of the kinds of ceramics made and used, there is still often just enough to make it possible to address questions about large-scale behaviour of societies. For example, attempts to model city-state formation in Archaic Greece largely make use of geography and the knowledge of significant sites, available despite the lack of systematic archaeological material, to form the basis for comparison. This example is couched in a framework of 'theory modelling' in which assumptions are made about the agency behind the formation of what, in practice, are exchange networks.

The situation is complicated by the presence of more (but not extensive) data. It is challenging to find a middle ground between generic theory modelling and detailed structuring of data (data modelling), from which agency is inferred rather than assumed. In this talk we shall discuss one approach using a (13,000+ artefact) data set from Late Bronze Age (LBA) Crete put together by one of us (PG) from published catalogues. This data is too much for generic modelling but (with only 1000 'useful' artefacts) too little for data modelling. Nonetheless, combining the data with geography, technology, assumptions about artefact function and general network analysis provides a dynamic avenue through which to explore the role of key Cretan sites during the LBA.

Female Networks in the Late Roman Republican. *Gregory H. Gilles*

This paper will present current findings from my PhD research on female agency in the late Roman republican. My PhD is using female centred networks to connect women during this period as visualisation makes it easier to identify different patterns of connectedness (social, familial and/or political), then simply reading about these connections from static texts. My research primarily uses the newly conceptualised Digital Prosopography of the Roman Republic from KCL, as well as verified ancient sources, to identify familial connections within four generations (one above and two below) of the various central female nodes. Focussing on four generations not only enables the identification of possible repeated familial connections, but new connections forged with powerful new men or families in subsequent generations as well.
It is hoped that the numerous and varied female centred networks will answer the four main questions raised from the literary review undertaken for my PhD:

- Were marriages mainly used to cement, or initiate, political alliances between powerful men and/or families?

- Was the, often, great age disparity between spouses intentional and the norm, or was it simply due to the military and/or political careers that Roman men had to undertake before they could marry?
- Was a rich widow or divorcée an attraction for politically aspiring new man/impoverished noblemen?
- Did stepmothers play an active role in the upbringing of their husband's other children?

This paper will showcase the networks that I have already created and demonstrate how they can be used to answer these questions. The issues with the data, and their impact on the creation of these networks, will also be discussed.

Social networks, tradition, and innovation in the potters' quarters of ancient Athens. *Diane Harris Cline (George Washington University) and Eleni Hasaki (University of Arizona)*

The *Kerameikos* (potters' quarter) in Ancient Athens was bursting with potters producing vessels for the household, for dedications in sanctuaries, and last offerings in cemeteries. For the painted pots, specialists through connoisseurship studies have identified more than 1,300 artists (as distinct 'hands') and established ties between them, The seminal works in print are Beazley's *Attic Black-figure Vase-Painters (ABV)*, and *Attic Red-figure Vase-Painters (ARV)*which laid the foundation for the Oxford Beazley Archive Pottery Database. Bridging connoisseurship with organization of production through SNA is the obvious next step as SNA can provide an innovative and quantitative method to map these relationships that fits well with the groundwork previous scholars have already laid.

Converting connoisseurship-based attributions into SNA edge-lists has been challenging, exacerbated by the very structure of the online databases, which are excellent for producing lists of vases attributed to any given potter, but were not built for extracting relationships between potters. Our translation of Beazley's *ABV* (just the black figure vases) has produced 683 nodes and 776 ties and helped identify the key players in the *Kerameikos*. It also led to an enhanced understanding of how potters and painters chose to specialize in shapes with similar fields and curvature of decoration. Through our SNA of the Athenian *Kerameikos* we can obtain a panoramic view of how an industrial quarter was connected, who was central or peripheral, who influenced whom, how ideas moved across time and space through relationships, and how new technologies and stylistic advances spread through pottery communities of practice within and outside Athens.

Intellectual and Material Networks over the Long Eighteenth Century. *Mark J. Hill (University of Helsinki) and Ville Vaara (University of Helsinki)*

This paper uses the *English Short Title Catalogue*(ESTC) as a representation of material history - and historical networks - to measure changes in intellectual networks over time (1640-1800) and space (within London, and between Britain and North America).

The ESTC, covering over 480,000 documents, is the 'comprehensive, international union catalogue listing early books, serials, newspapers and selected ephemera.' Through extensive processing of the catalogue, we have been able to extract 735,932 names, unified into 87,763 distinct actors (including authors, publishers, printers, illustrators, etc.), along

with the publication location for nearly all documents (1104 unique locations). By using this data to construct social networks (documents are edges and actors are nodes) the ESTC is transformed from a historical record into a representation of historical reality.

This data allows for diachronic and spatial analysis of intellectual networks over many decades. Specifically, we use this data to: map changing roles and relationships between actors over time (with particular focus on publishers, booksellers, printers, and authors); identify shifting intellectual communities within the larger network (religious, political, literary, and regional); and we are currently exploring how these different relationships interact and exist in different spaces over the eighteenth century - specifically within London, and between Britain and North America.

This work, we believe, makes useful contributions to both the temporal and spatial approaches to network analysis, as well contributing, more generally, to intellectual history and the history of the book.

Local exchange or long-distance exchange. A network approach to the late antique Silk Road. *Tomas Larsen Høisæter (The University of Bergen)*

Few if any trade routes are as vividly evoked in the popular imagination as the Silk Roads, envisioned as a vast network of routes and connections linking East with West across Eurasia. Yet in the research literature on the antique Silk Roads the debate over what drove the Silk Road system, and indeed if one can speak of the Silk Roads and a Silk Road trade at this early date at all, is still fierce.

This paper aims to examine this old debate from a new angle by employing network theory, both as a way of thinking about the Silk Roads and as analytic tools. Two main sources will be considered. Firstly the the Cadota documents from the late antique Kingdom of Kroraina, nearly 800 documents found mostly in archives in the abandoned ruins of Niya. Secondly, the slightly earlier Chinese chronicle of the Hou Hanshu which gives detailed descriptions both of the countries to the west of China and the connections between them. Through the analysis of the geographical networks visible through these two important sources the paper will discuss the various levels that Silk Road exchange appears to have operated on and how the interplay between larger and smaller networks seems to have been a key driving force in the larger Silk Road exchange network in antiquity.

Analysis of material culture: a network-based approach. *Sarah M. Griffin (University of Oxford) and Florian Klimm (University of Oxford)*

Museum collections consist of diverse objects, each of which is a physical manifestation of the culture within which it was made. While the art historical interpretation of these objects offers significant insights into these cultures, their analysis is limited to individual objects and the relatively small groups within which they can be categorised. We use a quantitative network-based approach for a large-scale analysis of the use of various media in the making of these objects. To do so we focus on metadata of the objects, specifically that concerning their materials and techniques.

We create a network of more than 4,000 different materials and techniques, and combinations of both. We then employ various network-analysis tools, such as centrality measures and community detection, to identify significant patterns, with a particular focus

on temporal ones. This allows us to track the prominence of a given material throughout the history of man-made objects and identify how certain materials were used with one another. While our approach is suitable for the analysis of specific collections and large data sets alike, we focus on the collection of *The Metropolitan Museum of Art*(New York), which includes more than 500,000 objects, representing more than 5,000 years of art from around the world. In addition to identifying the patterns which emerge within this collection, we also discuss general challenges encountered when working with large museum collection data sets.

Tracking spatio-temporal social networks in Northern New Zealand: A case study on the origins of Māori society. *Thegn Ladefoged (University of Auckland), Caleb Gemmell (University of Auckland), Dion O'Neale (University of Auckland), Alex Jorgensen (University of Auckland), Hayley Glover (University of Auckland), Christopher Stevenson (Virginia Commonwealth University) and Mark McCoy (Southern Methodist University)*

Archaeologists regularly claim to reconstruct the origins of new types of societies through the analyses of artefacts. This study centres on the Polynesian colonists who settled New Zealand and touched off the creation of a type of society not previously found in remote Oceania. Over the span of several centuries in this large sub-tropical landscape relatively autonomous village-based groups transformed into larger territorial lineages, which later formed even larger geo-political tribal associations. Our interdisciplinary project evaluates where and when new social forms came into existence in relation to diverse social and environmental contexts. We are developing social network analysis of the spatial and temporal distribution of obsidian artefacts, an important stone resource that was used for a variety of tools. Eventually incorporating data from over 40 previously excavated Northern New Zealand assemblages we are using pXRF sourcing of obsidian artefacts to determine the flow of material and developing obsidian hydration dating to establish relatively precise chronologies. Our spatio-temporal network analysis is providing insights into how Māori fused historical contingencies with economic considerations during the transformation of society from village-based groups to powerful lineages and tribes.

Percolation robustness and the deep history of regionality. *Mark Lake (University College London), Theo Brown (Helyx Secure Information Systems) and Simon Maddison (Independent Researcher)*

This paper directly address the conference question "How did geography constrain or enhance the development of past social networks?". It has long been argued that the different settlement patterns in Britain reflect topographical variability, for example Fox's lowland and upland zones, the "Central Province", etc. A key question is whether topographic barriers and corridors have substantially influenced patterns of connectivity that in turn underwrite a deep history of British settlement pattern. Recently archaeologists and others have turned to computational percolation analysis to address this question (Arcaute et al, in prep, "Case studies in percolation analysis: the distribution of English settlement in the 11th and 19th centuries compared", J. Arch, Sci.), but there has been little attempt to establish the robustness of clusters/networks produced by percolation in the face of, for example, locational uncertainty. This paper will describe a new method of sensitivity analysis for percolation and demonstrate its application to the classic problem

of the existence and bounds of a "central province" in British settlement (Roberts and Wrathmell, 2000, An Atlas of Rural Settlement in England).

Diachronic Entanglements at Çatalhöyük: Tacit knowledge and data-scaffolding of person-thing networks. *Angus Mol (Leiden University) and Dominik Lukas (Stanford University)*

This paper presents the results of a project that evaluated the potential of network approaches to inform on Hodder (2012)'s theory of entanglement. Even with current advances in archaeological network analyses, the study of entanglements, a theory of person-thing dependency, has remained challenging. This project in particular looked at the difficulty of (1) visualizing the formation of entanglements created through heuristic processes and (2) the challenge of analyzing entanglements through time. These issues have been jointly explored in a case-study of entanglements at Çatalhöyük that spanned the entire occupation of the site and several major social, cultural, and technical developments in the history of this community. The approach presented here rests on two pillars: network visualizations based on tacit knowledge of Catal's entanglements and deterministic, data-scaffolded models. In the latter approach, archaeologically observable and quantifiable phenomena have been used to pinpoint and connect key entanglement events.

Entanglement theory, especially as applied in the context of the rich archaeological record of Çatalhöyük, may be considered a one-of-a-kind case in archaeological network application. Yet this paper will outline how entanglement-network studies can be seen as exemplary of the wider potential and challenges of network approaches to the deeply heuristic, socio-material, relational thinking that pervades archaeological theory.

Building the Church in the Late Antique West (380-450 CE): a Social Network and New Institutionalist Approach. *David Natal (Royal Holloway)*

The late antique western church was a fragmented institution with very few mechanisms of policy implementation and coercion. And yet, clerics from around the Roman world sometimes respected the incipient ecclesiastical hierarchy, resorted to common laws to defend their positions, and respected the decisions taken in distant ecumenical councils. This paper argues that the existence of clerical interactions favoured the dissemination of common ecclesiastical rules, ecclesiological visions, and patterns of clerical behaviour that helped to strengthen an organisational structure with some degree of accountability and cohesion. In particular, I will focus on analysing how specific structures of clerical networks contributed to consolidating the church's provincial geography and to reinforcing the authority of metropolitan bishops.

This paper stems from research conducted within the project 'Connected Clerics: Building a Universal Church in the Late Antique West (380-604)', funded by the ERC-Starting Grant scheme. By applying social network analysis and new institutional theory to the scant and scattered late antique material, this project seeks to test the validity of these sociological approaches for less-documented institutions, such as the late antique church.

Relational history: network analysis, oral history and the Nazi camp archipelago.
Alexander Prenninger (Ludwig Boltzmann Institute for History and Society, Vienna)

The vast complex of c. 42,000 Nazi camps included a vast series of different types of camps: transit camps, ghettos, prisoner-of-war camps, forced labour camps, Gestapo camps etc. Despite extensive research, we have only limited information about the functions of specific camps within this "archipelago" and the connections between the different camps. When and why specific groups of prisoners were sent from one camp to another has not become the topic of the research agenda or has been limited to detailed studies on a specific camp.

From my research on a collection of c. 850 interviews with survivors from the Mauthausen concentration camp, it is possible to trace the trajectories of survivors from almost all of German occupied Europe through the Nazi camp system. Grounded on a database comprising data from the interviews, questionnaires and archival sources, a historical network approach has been proven to be an effective method to analyse the different trajectories of different groups of prisoners (e.g. Jewish vs. non-Jewish). A close analysis of the trajectories shows that in different parts of German occupied Europe different types of internment were used for specific types of prisoners. The many transports from one camp to another experienced by these survivors give us the possibility, beyond the individual trajectories, to analyse the interconnectedness of camps in the German occupation and persecution policies during World War II. The workshop would be an excellent opportunity to discuss my approach and to enlarge my methodological and technical knowledge in network research.

Studying the networking system between medieval strongholds (Forts and Fortalices) of Garhwal Himalaya: A case study of Chaundkot fort. *Nagendra Singh Rawat (Hemvati Nandan Bahuguna Garhwal University), Vinod Nautiyal (Hemvati Nandan Bahuguna Garhwal University)*

Communication is in the roots of all societies, in which 'networking' is an important artificial component. Networking represents advance skills of communication, developed in various forms and patterns. The study of strongholds explored in Garhwal Himalaya exhibits the example of complex networking system indigenously developed during Medieval period. The configuration pattern of Strongholds (fort and fortalices locally known as *Garh*and *Garhi*) reveals two kinds of networking patterns formed by the chieftains of this region *e.g.*- (a) Local Network; which was spread within a valley or jurisdiction of any particular ruler, (b) Wider or Supra Network; this network can be named as 'Network of Networks' as it spreads beyond the valleys and connects the major strongholds of Garhwal with the main seat of power through visual (fire and smoke) and sonic signals (specified sound beads). However, it has been hypothesised that the 'supra network' was developed by the Ajaypal of Parmar dynasty who brought all the chieftains under his rule in 15thCentury CE. But recent study pushes the chronology of fortification to 9thcentury CE. It indicates that the idea of networking emerged in the last centuries of first millennia, which was in vogue till 15thcentury CE in this region. Therefore, on the basis of this, the present paper will illustrate the role of strongholds and their distribution in networking system developed by the chiefdom society of Garhwal Himalaya in medieval age.

Dealing with uncertainties, data-biases and long-term perspectives: A methodological implementation to test Mediterranean Networks and seaborne routes between 8BC-5AD. *Manuela Ritondale (University of Groningen) and Luce Prignano (University of Barcelona)*

During the past three years we have used network theory to study the cargo composition of Mediterranean shipwrecks with the aim to uncover changes in Mediterranean connectivity and seafaring strategies between the 8th century BC and the 5th century AD.

This diachronic analysis was based upon the assumption that the association -onboard of shipwrecks- of certain categories of archaeological data, particularly those whose provenance and chronology is known, may provide information on commercial contacts between Mediterranean regions.

However, the theoretical and methodological limitations connected to such a long-term perspective, as well as the many biases affecting the available archaeological evidence, impose the need for definition of strategies to test the significance of the outcomes and overcome the data-uncertainty.

This paper will propose solutions to the above issues while debating advantages and drawbacks in the application of computational techniques to the study of maritime trades. Particularly, a novel technique of network randomization based on constrained resampling will be discussed.

Our conviction is that incompleteness and uncertainty are ubiquitous in archaeological datasets; nonetheless, the acknowledgement and the proper statistical treatment of data-biases may lead to further improvements of a model instead of constituting a limitation for its development.

Harbours and nets in the Levant. *Anja Rutter (Christian-Albrechts-University/Kiel)*

The period of destructions between the LBA and the Iron Age I in the Levant have often been considered a complete breakdown of the densely interconnected LBA networks. The big political units expending resources for the maintenance and safe-keeping of land routes and harbours no longer existed.

However, some of the nodes survived into the Iron Age, as did a number of the connections. Maritime travel in particular not only requires safe anchoring places, it also needs a specialised skill-set that does not disappear with political breakdown and would likely be used whenever possible.

A diachronic comparison of networks should enable us to understand the impact of the disruptions on the connectivity of the region and of individual places. An analysis of the network character might allow an explanation of the breakdown process: cataclysmic by the elimination of a few central places? Gradual disintegration?

A complete network model to answer such questions would require a great body of varied data in comparable form. That does not exist. Very different levels of archaeological research, incomplete publications, a focus on prestigious sites all contribute to a very uneven basis of data.

The great variety of information reminds us to check mathematical network models against archaeological realities. The gaps unavoidable in archaeological data, on the other hand, raise questions about the processes of viable network research despite such limitations. They caution against presenting the results as scientific truth and boost the implementation of publication methods that allow recipients to follow the research process.

Creating networks from text with Recogito. *Valeria Vitale (School of Advanced Studies, University of London), Rainer Simon (AIT Austrian Institute of Technology), Elton Barker (The Open University), Leif Isaksen (University of Exeter), Rebecca Kahn (Humboldt Institute for Internet and Society)*

Recogito[1]is a Web-based open source annotation environment for texts and images. Its primary use case so far has been the annotation of named entities in historical documents – places in particular. By marking up place references, and linking them to *gazetteers*(digital geographic dictionaries), Recogito makes it easy to generate cartographic maps from literary sources. This talk introduces new functionality, which aims specifically at simplifying the creation of *networks*from text. Through an easy-to-use linking tool, users can draw connections between places, actors and events in the text. They can type these connections using their own vocabulary, and export the resulting data to other environments for further processing and analysis.

Since every annotation is uniquely identified, and resolvable over the Web, Recogito provides something that, to the best of our knowledge, network-centric environments for historical research currently lack: a seamless connection between nodes and edges of the network, and the literary evidence that was used to compile them. Working in Recogito is both a collaborative and an iterative process. Every statement – whether it is a marked up entity, user commentary, a tag, or a network connection – is attributed to the user who made it; as a result, it can be revised and commented on by others. At the same time, Recogito maintains version history, thus inviting an exploratory and experimental approach to annotation and interpretation, which applies as much to the context of scholarly research as to a classroom setting. [1]https://recogito.pelagios.org

Modelling Ptolemaic Pathyris as Nodes and Edges: a Critical Evaluation of Network Methods for Small-Scale Community Studies. *Lena Tambs (University of Cologne)*

The military camp of Pathyris in ancient Egypt has generated an unusually rich body of documentary sources revealing detailed information about the inhabitants, their interrelations and the socio-economic activities in which they participated. The current project studies c. 425 Greek and Demotic texts associated with 21 reconstructed archives. The documents cover a period of c. 75 years – or three generations (c. 165-88 BCE).

Social Network Analysis (SNA) offers a range of conceptual and digital tools for tackling the complexity and diversity of the source material. By means of modelling attested persons as *nodes* and relational information as *edges*, the project examines what the structural composition and network density reveal about life in this settlement and the influence of a person's or group's network position for various types of social and economic behaviours. In combination with other methods, SNA allows the significance of personal relations and social status in this ancient community to be studied on the basis of empirical data.

The talk critically evaluates the usability and relevance of network tools for studying ancient Egyptian texts. In doing so, the validity of selected results will be discussed by means of comparing observations resulting from the network analysis with interpretations reached through alternative methodological approaches.

Mapping Literary Cosmopolitanism: Three Methodological Challenges in the Digital Era. *Colton Valentine (University of Oxford)*

Studies on literary cosmopolitanism have, in the past decade, come to the forefront of digital humanities initiatives. Such data-driven analyses hold great promise for mapping literary networks, but they also pose new methodological problems. In my paper, I will focus on three such issues.

First, I examine the question of time scale. Most digital initiates focus on a single author (Voltaire and Locke at Stanford's Republic of Letters; Apollinaire at Harvard's metLAB) or on a confined historical time-period (Mapping the Enlightenment at UCL.) Yet cosmopolitan literary networks belie timescales of individual human lives and strictly-periodized epochs. Second, I turn to the question of space, underscoring how *longue-durée*studies must account for shifting spatio-political categories such as empire, state, and nation. Finally, I will look at an issue specific to the literary field: the difference between text-based and context-based approaches. Text-based approaches draw data from literary works themselves (Heuser and Le-Khac on the semantic field of the British novel; Heuser, Moretti, and Sterner on the emotional geography of London.) Context-based approaches use testimony such as correspondence and travel data (CatCor and Cultures of Knowledge at Oxford; Grand Tour at Stanford's Republic of Letters.)

In conclusion, I will reflect on what modeling and visualization tools might best address these methodological issues. How can literary scholars, I ask, develop models that 1) integrate multiple time scales, 2) annotate fluctuating spatial configurations, and 3) superimpose textual and contextual maps.

MonkBook': Towards an understanding of social networking in medieval monastic orders. *Harriett Webster (University of Wales Trinity Saint David)*

Today's society has come to be dominated by social media platforms such as Facebook, Twitter and Instagram; but the social network theory underpinning these 'big data' sets is nothing new. This paper will examine the possibilities open to scholars of the humanities who employ more quantitative methods such as network theory in order to ask new questions and make new connections in their research. Using the trailblazing 'Monastic Wales' website as a case study, we will examine how the comparatively 'tiny data' which survives from the Middle Ages can provide us with new and intriguing insights into supposedly familiar monastic networks.

Such connections include the change over time of relationships between monastic houses of the same and different orders. These have directionality, can be strong or weak, based on communication, economics, personnel transfer, or shared patrons. They could also be influenced by ties of 'corporate' identity or proximity and locality. By utilising the methodological tools provided by network analysis, these relationships can be explored beyond the usual confines of a particular order or geographical space. I also hope that my

'tiny' or 'partial' data sets will prove to be useful to project partners more used to complete big data.

Fundamental limitations of past states inference in complex networks. *Jean-Gabriel Young (Université Laval), Laurent Hébert-Dufresne (Université Laval, University of Vermont), Edward Laurence (Université Laval), Charles Murphy (Université Laval), Guillaume St-Onge (Université Laval), Patrick Desrosiers (Université Laval)*

Complex networks are not static objects. They map out dynamical systems, where nodes and edges appear and disappear in time. Years of success show that understanding how these changes shape real networks can explain many of their properties, across scientific domains. Simple dynamical models of networks' evolution---e.g., the preferential attachment model---are the corner stone of this line of research. They have famously led to satisfactory explanations of a number of macroscopic features of real networks, such as their small diameters and skewed distributions of degrees.

It is now understood that these models also offer a powerful description of the detailed structure of real networks through time. A striking consequence of this observation is that growth models can be used to reverse the clock of the networks they model, to peek at their past states.

In this contribution, we investigate the problem of past state inference ("network archaeology") from the point of view of Bayesian inference. We derive a full inference procedure for network archaeology, including a sampling algorithm for the distribution of past states, and an efficient approximation thereof. Our principled approach allows us to identify the fundamental limitations that arise in network archaeology. We find, for example, that the strength of the rich-get-richer mechanism involved in a network's creation largely determines our ability to infer its past. Our most important conclusion is that it is impossible to perfectly reconstruct the past of a network, independent of the details of its evolution. But despite these limitations, we show that it is possible to recover a significant quantity of information from incomplete data, and therefore that network archaeology is a worthwhile pursuit---as long as imperfect knowledge is tolerable.

Short Talks Plus Poster

The "Desert Networks" Project: Presentation, Methodology, and Initial Results of a Project on the Physical, Economic and Social Networks of the Eastern Desert of Egypt during Antiquity. *Bérangère Redon (CNRS), Chloé Aussaresses, Alexandre Rabot (University of Lyon)*

Since November 2017, the ERC-funded "Desert Networks" project has brought together an interdisciplinary team composed of archaeologists, historians, philologists and geomaticians, to explore the reticular organisation of the Eastern Desert of Egypt from the beginning of the New Kingdom (c. 1500 BC) to the end of the Roman period (c. 300 AD).The region is a hyper-arid desert, inhabited in antiquity by hostile animals and nomadic populations, but also richly provided with natural resources and acting as a conduit between the Mediterranean, the Red Sea and beyond. Thus, it has always been a tantalizing region for Egyptian people and powers. Adventurers and archaeologists have explored the area for almost 300 years. Its ancient remains are spectacularly well preserved and ancient sources about and from the Eastern Desert itself are numerous, including around 20 thousand inscribed potsherds (ostraka) used for daily correspondence. Yet despite recent progress, the history of its occupation and appropriation remains static and compartmentalized. The ambition of the "Desert Networks" project is to work in and on the Eastern Desert as a dynamic object, and to analyse the nature and evolution of the different networks (physical, economic and social) that linked its various component parts over time. In this presentation, we will outline the methodology and aims of the project, as well as some difficulties we faced, in particular due to the heterogeneity of our sources. We will also present the first results of our work, a social network analysis of the ostraka discovered in the Roman fort of Krokodilô that demonstrates the potential impact to such an approach to the Eastern Desert.

Provincial sculptural networks in the early Roman empire. *Penny Coombe (University of Oxford)*

The similarities between certain types of Roman sculpture found both in the Rhineland area of modern Germany and in Britain are striking. Motifs and forms are shared between the two areas, and certain types of votive or funerary monument can be seen, often in only these areas and not widely in the Roman Empire. Soldiers were moved between these two geographic regions, particularly in the 1st and 2nd centuries, and the army could have acted as agent in the movement of ideas and technique. However, there are several potential actors and factors involved in production of sculpture during this period, with different network patterns: sculptors, patrons, stone supplies, viewers. The detail of these interactions and the transmission from one province to another has been acknowledged (especially Stewart (2009, Hayward (2009), Cassibry (2015)), but requires further examination.

Traditionally qualitative approaches have been used to understand associations amongst these sculptures, but this is a topic ripe for new consideration of networks and application of network theory. This poster will consider the central question: how did networks influence the transmission of form and styles between the Rhineland and Britain in the early- to mid-Roman period? Building on the work of Collar (2013) on movement of religion, and on models of economic circulation of stone and art by Russell (2013) and

Harris (2015), case studies of auxiliary cavalry tombstones and mother goddess dedications will be examined to see how network theory can combine with qualitative research to understand the connections.

The Byzantine defensive network of Northern Puglia between X and XI century. *Dino Alberto Rapisarda (University of Florence), Sarah Murgolo (Rheinische Friedrich-Wilhelms-Universität Bonn) and Cosimo Damiano Diella (University of Florence)*

Towards the end of the 9th century AD, the Byzantines conducted numerous military operations in Apulia. They brought back a large part of this territory in the imperial orbit, in this way subtracting it from the control of the Lombards. Through these actions, northern Apulia became a border area.

The Byzantines decided to build a network of border castles both for defensive purposes and for land control. These fortifications, positioned between 500 and 1000 meters above sea level, were interconnected to each other, in particular regarding visibility. Their realization was evidently carried forward by the Byzantine imperial administration with some technical specifications: the different fortified sites, cited in the written sources and archaeologically attested, in addition to positioning themselves on reliefs, from which checking the border, were interconnected in terms of visibility, in order to coordinate, at any time, military operations and defense against possible attacks.

This would be demonstrated both by the visibility analysis, carried out through the use of the open source software Qgis, and by the analysis of light visibility, experimentally made with light signals. These light signals should have been used for fast communication between the settlements, creating an efficient communication and defense network.

Uncovering Networks within 700 years of material textual culture in the Arabic world. *Thomas Efer (Universität Leipzig)*

In this contribution we present ideas, datasets and challenges from the "Bibliotheca Arabica", a long-term project that aims to collect large-scale data on the arabic literary and scientific production and practice between 1150 and 1850 CE. With a focus on integrating digitized catalog data and collections of manuscript notes, the project aims to combine a curated compilation of existing bio-bibliographical sources and Linked Data collections with original research and structured scholarly normalization efforts.

The data in its various curation states is flexibly modelled (and will be entirely stored) within a graph database. The setup allows for a vast variety of queries, supporting a mixture of geo-temporal, property-based and network-topological filtering. It allows for explorative analyses within some sort of knowledge base formed by a very heterogeneous semantic network.

We show how the network research steps that follow after data exploration phases have to deal with an almost infinite number of "subnetworks of interest", according to the specific research questions. The need for adequate domain specific network induction techniques arises - after filtering, merging, clustering or applying co-occurrence-methods. Common analysis methods, centrality measures or community detection algorithms may not be suitable when all facts have obscured provenience and "missing links" may be results of unknown biases. In addition, an important yet unsolved issue on the way towards serious

quantitative research is how to generally estimate the level of (in)completeness of the collected data for specific data facets, literary genres, communities, regions and centuries of interest.

Stock Market Networks & Connectivity. Technology transfer between the Toronto Stock Exchange and the Bourse de Paris in the 1980s. *Johanna Gautier (Graduate Institute of International and Development Studies, Geneva)*

In 1985, the Chambre Syndicale of the Bourse de Paris purchased continuous quotation software from the Toronto Stock Exchange to automate market transactions: the *Computer Assisted Trading System* (CATS). It had been fifteen years since the very first automated stock exchange, the National Association of Securities Dealers Automated Quotations (NASDAQ), was created in New York in 1971.

This technology transfer was the result of long-term sustained collaboration between Canadian and French stock markets. More than 300 French stockbrokers went to Toronto to learn computer-based trading for two years until the machines were transferred to Paris in 1987. The urge for continuous quotation also stemmed from the competition between the Bourse de Paris and the London Stock Exchange, since the latter had achieved the automation of its services in 1985.

The study of this original transatlantic network, sharing technological breakthrough despite global competition for trading positions, will enlighten how international circulations underpin technology transfer and social practices.

Tracing the Transmission of Conceptions of Deity: Epithets of Jupiter in Roman Imperial Italy. *Zehavi Husser (Biola University)*

In my project I examine conceptions of the ancient Romans' highest deity, Jupiter, in Italy during the Imperial period by tracing the networks involved in transmitting components of the worship experience of the god including epithets employed, the purpose for invoking the deity, iconography, as well as how the god was propitiated. Here, I apply social network analysis to material and inscriptional data as a proxy for studying the transmission and distribution of ideas about the god in Roman Imperial Italy.

In the first part of this project, the focus of this paper, I analyze the geographical distribution of Latin and Greek epithets of Jupiter as observed in epigraphic documents (including building inscriptions, votive offerings, calendars, etc.) throughout Italy from approximately the 1stthrough 4thcenturies AD. Jupiter was worshipped with a large and diverse repertoire of epithets (e.g., Victor, Heliopolitanus, Terminus). Whenpresent as part of a god's name, the epithet is an important aspect of the perceived identity of a deity that has received little detailed treatment for Roman gods. Robert Parker (2003) has already shown for Greek deities how such epithets carry rich significance, and could specify among other things, a deity's perceived functions, associated rituals, and connections to ethnic groups. Where possible, I scrutinize the context of the use of the epithet, including the identity of the dedicator, the purpose of the dedication, and any ritual offered to Jupiter. I also provide preliminary hypotheses regarding possible routes of transmission of ideas concerning the god.

Using networks to update an unfashionable archaeological concept: the Atlantic Bronze Age as a complex web of different and changing connections. *Juan Latorre-Ruiz (University of Oxford)*

Since its creation in the 1940's, the "Atlantic Bronze Age" concept has been used to refer to the different types of similar bronze metalwork found all over Atlantic Europe. However, each author has defined it in a different way thinking of it as a culture, a group of cultures, a technological complex, a mentality, etc. Partly because of this, in 1998 its validity was questioned in the congress "Is there an Atlantic Bronze Age?" and since then it has been barely used with a few exceptions. Although different, previous definitions of the Atlantic Bronze Age thought of this concept in the same essentialist or normative way. They understood it as set of components, for example certain metalwork types or "cultural" traits, present in the different regions of Atlantic Europe. The problem is these cannot be found in all of them and this has been one of the main arguments used to question the validity of the concept. In this case, the Atlantic Bronze Age is approached using networks. To do so the distributions of metal artefacts of the same type are represented as networks on which metalwork are the nodes and the links between them the voyages people made to introduce them in other regions. By doing this, it is possible to build over the map of Atlantic Europe an overlapping web of networks each representing one type of artefact and the voyages made to distribute it. Each link connecting the regions of Atlantic Europe in different ways and linking people with different ethnicities, cultures or identities. Nevertheless, they were all part of a larger network of contacts that existed to satisfy a local demand for metals that although probably different in each place was common to all the regions of Atlantic Europe. In this work it is proposed that those different and changing connections is what should be labelled "Atlantic Bronze Age" and what ultimately created it. Consequently, the result of this study is not a new definition of this concept but a new model to understand and study it. In this model studies about the Atlantic Bronze Age should not focus in finding what all the regions of Atlantic Europe had in common but the different and changing nature of the links connecting them.

Inferring temporal networks based on spatial localization. An application to organic dairy production in the USA: 2002-2015. *Juan Carlos Sanchez Herrera (New York University)*

Establishing an organic dairy production facility involves barriers to entry such as certification costs, land, capital, labor, know-how, risk aversion, and potential discrimination from traditional dairy producers. We study the role of networking in the geo-localization of organic dairy producers in the USA between 2002 and 2015.

Given a temporal dataset of organic dairy certifications, we simulated temporal networks based on geo-localization. For each new producer we created a 50-mile boundary around them. Afterwards, we inferred social networks by connecting them with new and established producers within this radius. For the simulation we chose different social sociability behaviors from a 5% to 100% probability of connecting with other producers in the 50-mile radius. Afterwards, we used network analysis to study the inferred networks.

The results evidence that the geo-location of new organic dairy producers reflects advantages from proximity to peers such as potentially benefiting from knowledge

spillovers, know-how transmission, minimizing risk arising from uncertainty, and minimizing discrimination towards organic production.

Using this methodology we infer social networks without data on actual connections. The simulations take into account a variety of possibilities and degrees of agent sociability's. We believe that this methodology can inform and inspire other researchers who seek to overcoming the burdens from lack of real life connection data and enabling the use of geo-location that possibly reflects social phenomena occurring from proximity to other social agents.

Mapping Mithraic Cult Iconography using Network Analysis. *Kevin Stoba (University of Liverpool)*

The central cult image of Roman Mithras-worship, termed by modern scholarship the *tauroctony*, features Mithras stabbing a bull (usually in the shoulder or neck) often surrounded by two torchbearers, a series of animals, and depictions of Sol and Luna. It has been found throughout the Roman world, from Syria to Spain and from Egypt to Britain, with concentrations in Rome and along the rivers Danube and Rhine.

However, every element of the scene is prone to great variation, both between and within regions, and even at individual sites. Reasons for this variation can range from the superficial (artistic preference, miscommunication/misremembering of details) to the profound (differences in concept and cult practice, changes driven by influential individuals within local groups, or interactions with other local religious forms).

There has only been one serious attempt to chart these differences: LeRoy Campbell's research in the 1950s-1960s. Scholarship still refers to Campbell's work, while acknowledging that it is misguided in tracing all Mithraic iconographic forms back to Persian antecedents. Campbell's work is, nonetheless, more fundamentally flawed, as it relies on a simple typology of tauroctonies (mostly based on the structure of the image as a whole), resulting in monuments which are divergent in many details being forced together to fit into Campbell's broad categories.

My presentation shows how the network analysis of variables within tauroctonies provides a more nuanced view of their diversity, and hence reveals more about the characteristics, relationships and inceptions of variants of Mithras-worship, and how they spread around the Roman world.

Networks of text reuse in early Chinese literature. *Donald Sturgeon (Harvard University)*

The phenomenon of text reuse – syntactically and semantically similar fragments of text repeated apparently independently in multiple pieces of writing, and often in works purporting to be composed by entirely different authors – is extremely widespread in early Chinese literature. Such reuse is typically unattributed, and its existence is often revealed only through painstaking comparison with other pieces of potentially related writing. Computational methods have for the first time made feasible the comprehensive identification of such reuse throughout large corpora of material, and have thus made practical studies based on patterns of reuse which emerge at much larger scales than had previously been possible to consider.

This work uses network analysis to investigate patterns of text reuse in the early Chinese corpus and the relationship between these patterns and difficult questions of authorship attribution within these texts. Using detailed data on individual instances of text reuse created through an exhaustive automated study of the entire transmitted corpus of Chinese from the earliest transmitted works through to those dating prior to the end of the Han dynasty (220 AD), this study demonstrates the utility of network visualization and analysis in identifying and exploring patterns of text reuse which shed light on the authorship of these early materials.

Network of Motifs - Applying Network Analysis on Multi-Sided Aegean Seals.
Martina Trognitz (Universtity of Heidelberg and Austrian Academy of Sciences)

In my ongoing doctoral thesis I am anaylsing a set of just over a thousand Minoan and Mycenaean seals with more than one side for sealing. These multi-sided seals are all published in the "Corpus der minoischen und mykenischen Siegel" and digitised in the Arachne-database of the DAI and the University of Cologne.

The central question of this work is if there exist specific patterns for combinations of different motifs on the seal faces. An example of such a pattern could be the combination of the depiction of a human, an animal, and a vessel on a three-sided seal.

On the way to answer that question lie further questions, such as "Which combinations of hieroglyphic signs were used?", "Which creatures were frequently depicted together on one seal?" or "Which hieroglyphic signs were used together with which creatures?". These questions can be investigated with methods from network research.

A graph database in Neo4j was set up, to serve as a basis for the creation of one-mode as well as two-mode networks. The database also takes into account uncertain information (e.g. for uncertain find places or not clearly discernible creatures).

The database as well as the results from network research and issues resulting from the dataset shall be presented.

Mapping Exegesis: Networks of Scholars and Readers in the Carolingian World.
Clare Woods (Duke University)

Carolingian scholars expended a great deal of energy and ink producing Biblical commentaries, perhaps more so than on any other literary or theological endeavour. Networks of scholars, students, and patrons emerge from the dedicatory letters and prefaces that frequently accompany these commentaries, but beyond these initial exchanges, patterns of circulation are difficult to discern. For Carolingian commentaries on three Biblical books in particular - Genesis, Matthew, and the Pauline Epistles - a substantial number of early medieval manuscripts survive. Despite this wealth of physical evidence, scholars of networks rarely introduce manuscripts into their analyses or discussions. This paper demonstrates ways to map the material evidence, and how we might interpret the patterns that emerge when we do so. Although early medieval manuscripts often have few if any precise indicators of when and where they were produced, newer digital tools such as NodeGoat - a data management, analysis, and visualization tool - allow us to use "fuzzy", pre-modern data in more sensitive ways. I argue that in finding ways to visualize as much of our manuscript data as possible - allowing, in other words, the material evidence to speak

for itself - compelling patterns emerge that invite further interrogation. By mapping the manuscript data with timelines, this paper provides a clearer picture of how exegetical texts might have been distributed, and opens up new ways to investigate connections between authors, readers, and patrons.

The Connected Past 2019

Do you want to host the next Connected Past?

The Connected Past has organised practical workshops and conferences about once a year since 2012. The scientific committee is currently looking for a host for its 2019 and 2020 events. These can take the form of a major international inter-disciplinary conference such as the current event in Oxford, or it can be focused on a particular discipline or topic. As long as the event concerns network research for the study of the human past, which is the research interest that binds The Connected Past community together. We encourage everyone who is interested in this, at any stage of their careers and anywhere in the world, to send us an expression of interest via email to pastnet.contact@torch.ox.ac.uk

Venue Map

Taylor Institution (A): Conference venue 6-7 December
Taylor Institution, St. Giles, OX1 3NA

History Faculty (B): Workshop venue 4-5 December
41-47 George St, Oxford OX1 2BE (entrance around the back)

Trinity College entrance (C): Wine reception 6 December
Broad St, Oxford OX1 3BH (enter porter's lodge)

Train station (D); Main bus station for airport buses (E)