

COMPLEX NETWORKS IN ARCHAEOLOGY: URBAN CONNECTIVITY IN IRON AGE AND ROMAN SOUTHERN SPAIN

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Abstract

In this article we highlight some of the issues surrounding the study of past urban connectivity and how archaeologists can deal with them by adopting a complex networks research perspective.

The ‘Urban Connectivity in Iron Age and Roman Southern Spain’ project focused on the various social, economic, and geographical relationships apparent between urban settlements [1]. The study area covered the central and western portions of the Roman province of *Baetica*, one of the most densely urbanized provinces of the Empire [2]. Archaeological data was collected for a core group of 190 sites, including data types as diverse as coins, ceramics and visibility in the landscape (Fig. 1).

Traditional approaches to the archaeology of Roman southern Spain have neglected the study of inter-urban connections [3]. For example, Iron Age (ca. 5th c. BC to 3rd c. BC) and Roman (ca. 3rd c. BC to 5th c. AD) sites are often studied independently even though they are part of a single long-term cultural process [3]. Our project aimed to explore how Iron Age communities were integrated into the political and economic structure of the Roman Empire. Moreover, we believe that the study of different data types in isolation devalues a key feature of Roman provincial landscapes: the underlying social, economic and political relationships between sites and across regions.

We developed a multi-scalar network approach (Fig. 1) that would help us explore a dataset of over 200,000 records and confront different data types distributed over a large area and dated with differing precision within a period of ten centuries. Two-mode networks of sites and data types on different chronological and geographical scales were created and compared through network analysis software (we used Cytoscape [4]). Our exploratory network approach was

shaped as an answer to two dominant factors: chronology and data provenance.

Chronology was an issue because of the sheer number of sites and material data types included. We noticed for example that different archaeologists used terms like *Early Empire* and *Early Roman* to describe the same kinds of material on different sites. Our objects are also grouped in over 300 data categories. The precision of the standard chronologies of each of these categories varies greatly. We therefore decided to explore the dataset through five fuzzy *time-slices* (Fig. 1). This approach allowed us to compare data networks of the most short-lived patterns evidenced in securely dated finds up to the long-term evolution of material remains from the Iron Age to the Late Imperial period.

The available data from Roman *Baetica* are unusually dense and complex, and distributed widely between institutions and individual specialists [2]. Combining such data without losing its integrity is a significant provenance issue. Consequently we decided to include the archaeological and research contexts for all data entities in full detail, e.g. for each pot fragment the earth layer where it was discovered and its published source were recorded, where this information was available, and added to the networks as node attributes. Our multi-scalar network approach allowed us to explore all the collected material from the single coin up to the entire region without losing track of data provenance (Fig.1).

The ability to compare networks of multiple data types through time and space obviously leads to large and complex patterns. However, we found a networks approach ideal for guiding us towards interesting or curious patterns, more so than say geographical visualiza-

tions. Our network exploration started from the bottom-up, where the assemblages of key sites were compared. This helped us to explore how these assemblages contributed to patterns visible on a regional and provincial scale, and how they changed through time. The exploratory phase led to a critical awareness of provenance issues surrounding the collected data and of our assumptions about urban connectivity in the area. The networks of archaeological data seem to indicate that in Roman times there was a broad continuity of Iron Age urban settlement and that from then on networks of communities became increasingly focused around key urban centers interacting internally and externally in myriad ways [1]. A complex networks approach allowed us to examine for the first time the evolving structure of inter-urban interaction in the study area as it is reflected through a wealth of empirical evidence. In doing so this project has provided a framework of urban connectivity for more detailed studies of individual sites [1].

References and Notes

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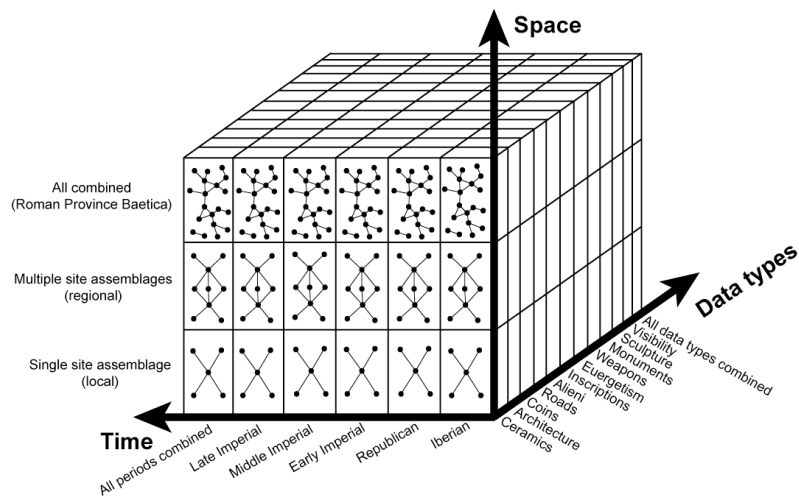


Fig. 1: schematic representation of multi-scalar network creation for data exploration.