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Research Article

Complicating an early state: a social network analysis of agents in Wari art (*c.* AD 700–850)

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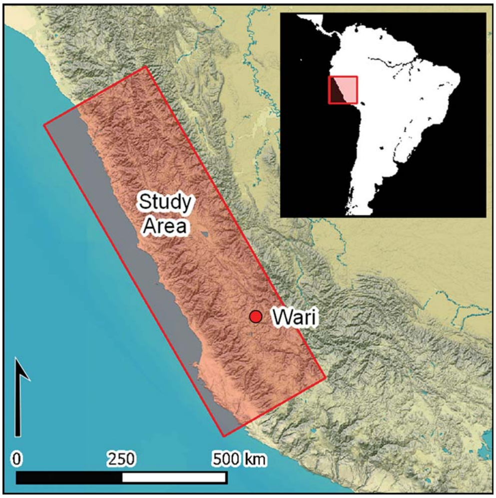

Processual models of the early state envisioned hierarchical societies with stable social and political structures. More recent research, however, has questioned this vision. Here, the authors explore Middle Horizon (AD 700–1000) Wari state iconography to provide an example of early state social and political organisation from the Central Andes. Social network analysis (SNA) of human figures ('agents') depicted in Wari art identifies links between individual agents, as visualised on objects and between the objects' findspots. The results suggest that the Wari state was more heterarchical than previously imagined. Similar applications of SNA could be used to explore the iconographic evidence of other early, pre-literate states around the world.

Keywords: Andes, Wari, Middle Horizon, social network analysis, iconography, heterarchy

Introduction

Archaeologists are increasingly recognising considerable variation in the expansionary dynamics and political organisation of early, state-like polities (Smith 2012; Fargher & Heredia Espinoza 2016; Feinman 2018), most of which lack written records through which to appreciate their diversity. Iconography, however, can be used to provide insights into their social and political organisation. Here, we use social network analysis (SNA) to investigate Wari, an early state in the Central Andes that dates to the Middle Horizon (AD 700–1000). Evaluating an array of human images known as 'agents', our SNA helps to illuminate geographical and social relationships, and provides a case study of how the application of this technique might be used to explore the iconography of other early states.

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Complicating the processual early state

Deriving from late nineteenth-century Western thinking (Brown 2002: 457–69), the processual model of the early state emphasised regionally organised societies composed of ruling and commoner classes, and highly centralised and internally specialised government. These were stable social and political edifices, with powerful rulers controlling quotidian affairs. Since the 1970s, archaeologists have sought to reassess this model (e.g. Johnson & Earle 1987: 246; Marcus & Feinman 1998: 4). The reassessment has been twofold. First, most scholars now recognise that earlier models overstate the cohesion, nimbleness and reach of early states (Brumfiel 1992; Khatchadourian 2016). These polities are now seen as fraught with internal strife, ever struggling to implement their limited power over surrounding communities (e.g. Richardson 2017). Second, processual models are now considered as too narrow (Yoffee 1993; McIntosh 2005; Kenoyer 2008); councils, competing clans and other social structures that were more flexible and less hierarchical could also organise large populations into state-like entities (e.g. Green 2021).

Thus, early states are now thought to have been more heterarchical than previously conceived. Unfortunately, 'heterarchy' is difficult to define. Is it, for example, "an organizational form of distributed intelligence" (Stark 2009: 19), "a partially ordered level structure implicating a rampant interactional complexity" (Kontopoulos 1993: 381), or "the collective and dynamic management strategies that undergird forms of exchange" (Crumley 2015: 12)? The term is better defined by what it is not: classic hierarchy, with a leader at the top, elites in the middle and subjects at the base.

While agreeing with many of the critiques of the processual state, we argue that alternative models of the political structure of early, state-like organisations remain poorly developed and inadequately fleshed out. In particular, most alternatives are derived from contemporary analogies or based on historically documented societies (Claessen 1978; Blanton & Fargher 2008). The earliest state-like organisations, however, were probably more 'heterarchical' as their inchoate political institutions came into being. In order to explore these early political structures, archaeologists have considered a variety of data, from household assemblages (e.g. De Lucia & Overholtzer 2014) to indices of labour organisation (e.g. Abrams & Bolland 1999). The application of SNA to iconography provides another tool for understanding these early, state-like polities.

Social network analysis and archaeology

Social network analysis is an approach that conceptualises social structure as a network of ties between entities; it focuses on the nature of the ties that binds these entities together and seeks to characterise the types of communities that these ties create (Wetherell *et al.* 1994: 645). Typically, SNA uses 'nodes' and 'links' to visualise a network and then applies graph theory to interpret the nature of the community formed. Nodes are the entities being studied—most often a set of individuals—and links are the ties that bind the individuals together, such as friendships, a purchased product, or shared political affiliation.

The resulting networks of nodes and links are often visualised in sociograms of interconnected circles and lines. Circle size, colours, line thickness and other features are used to

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provide more visual information about the network. Further visualisation techniques help to highlight aspects of the network, and a variety of statistical methods can be applied to characterise and compare networks with rigour (Wasserman & Faust 1994; Scott 2017).

SNA has been widely applied in archaeology, especially over the last two decades (for discussions of SNA in archaeology, see Knappett 2013; Mills 2017; Peeples 2019). Except for a few studies, such as that of Munson and Macri (2009), which examined elite ties using hieroglyphic evidence, the nodes used are usually settlement sites. The links between settlements tend to be imported artefacts or shared decorative elements, such as those on ceramics (e.g. Lulewicz 2019; Birch & Hart 2021). Previous applications of SNA to early states share this focus on settlements and mutual assemblages, improving our understanding of incipient economic, political and social relationships (e.g. Kerig *et al.* 2019; Vela 2019).

Earlier SNA approaches that provide particularly nuanced insights into early state politics have made use of written records. In the context of ancient Egypt, for example, the application of SNA has illuminated the role of kinship—both real and fictive—in political organisation (Martinet 2013; Chollier 2019). The earliest states in Egypt, and elsewhere, however, emerged before the advent of writing, or generated scant records. Extant iconography, on the other hand, is often available from these early states. Here, we argue that the application of SNA to such iconographic evidence can help to reveal some of the contours of early political structures.

Wari and Middle Horizon agents

By the end of the eighth century AD, the Wari polity had started to expand out from Ayacucho, a highland valley 330km east of Lima, Peru (Figure 1). The ensuing spread of Wari-style art and architecture defines the Central Andean Middle Horizon. Huari, the polity's capital, swiftly became the largest city in the Andes—extending to as much as $10km^2$ in area (Isbell 2001, 2009a)—and was characterised by substantial variation in social statuses expressed through architecture, artefact assemblages and funerary practices (Isbell 2004). Evidence of investment in agricultural infrastructure and of change in regional settlement patterns have led to a scholarly consensus that Wari was one of the first states in the Andes (Isbell & Schreiber 1978; Schreiber 1992).

The political organisation of the Wari polity and the mechanisms behind its spread, however, remain opaque. Although Wari authorities are often inferred, there is no clear evidence at Huari for palaces or primary temple complexes. The largest public spaces within early Middle Horizon Huari could hold just a small fraction of its population, and there is little that suggests centralised urban planning (Pérez Calderón 1999; Isbell 2009b; Ochatoma Paravicino *et al.* 2015). Instead, in the first two centuries of the Middle Horizon, Huari, along with other Wari settlements, were organised around the independently built and maintained compounds of extended households.

Judging from depictions of warriors, prisoners and human sacrifices across a variety of media that date to around AD 800, the expansion of the Wari polity was violent (Cook 1994; Isbell 2007: figs. 3.15A & B; Ochatoma Paravicino 2007; Knobloch 2010). Dozens of outlying Wari-affiliated sites were established, and sumptuary objects, such as spondylus from Ecuador and parrot feathers from the Amazon, arrived at Huari from across the Central

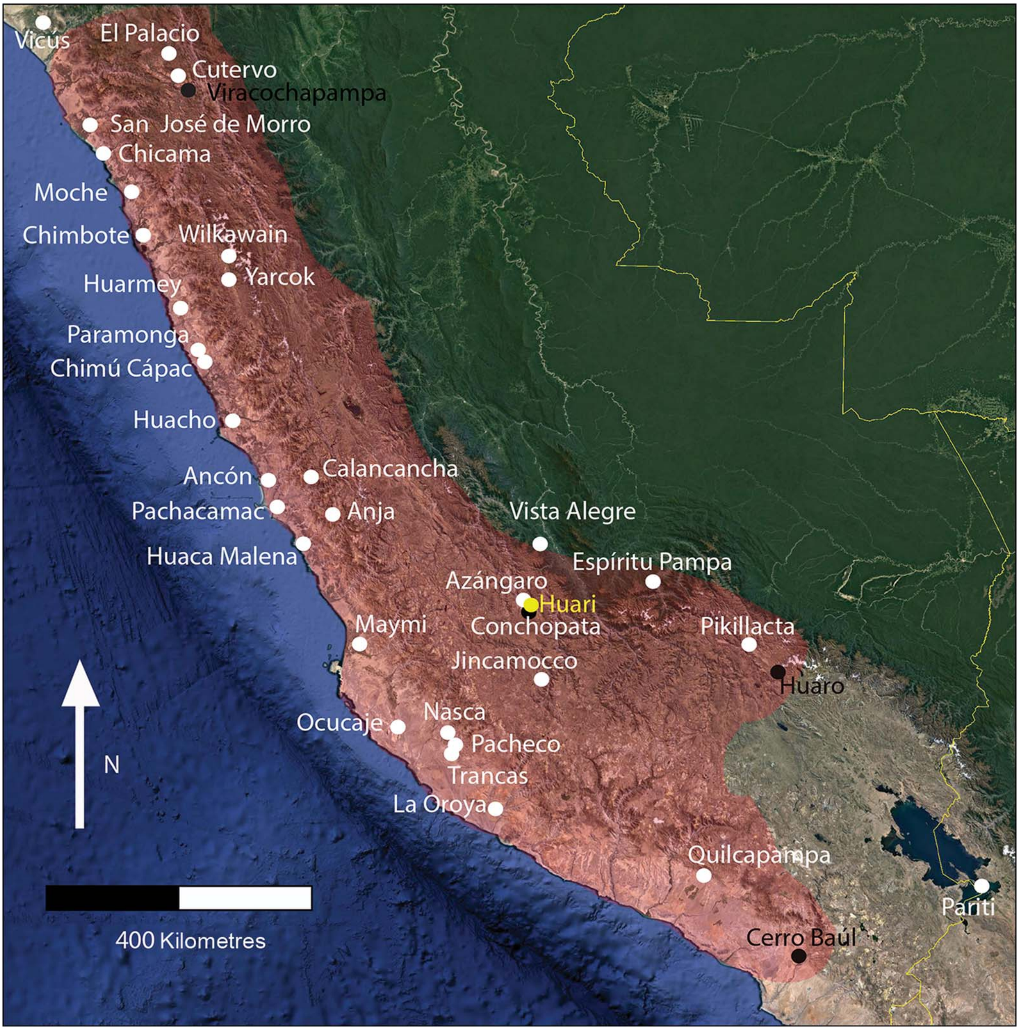

Figure 1. Landsat image of Peru, showing the extent of Wari influence in red. The city of Huari, highlighted in yellow, and the locations in white feature agent images. No agents have yet been documented in the three Wari-affiliated settlements in black (map by the authors; base map: Google Earth).

Andes and beyond (Jennings & Craig 2001; McEwan & Williams 2012; Rosenfeld *et al.* 2021). The nuances of Wari expansion, however, remain unknown, as do the relationships between Wari-affiliated colonists, circulating prestige goods and local populations (Jennings 2010).

We contend that information about this polity's expansion can be found in the examples of Wari art, which feature a repeating suite of humans with distinct costume and facial markings. Depicted primarily in ceramics (often face-necked jars, cups and serving vessels), these individuals can be distinguished from representations of deities, who are shown with crossed fangs and vertically divided eyes (Menzel 1964, 1968; Cook 1994; Knobloch 2010). Here,

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we use the term 'agent' for these human individuals to emphasise the active role they played in shaping Middle Horizon society (Dobres & Robb 2000). We assume that the men and women depicted as agents in Wari art represent individuals, or are stand-ins for kinship or ethnic groups. Some agents are almost certainly Wari-state actors, while others may represent their allies or rivals from different parts of the Central Andes. Such relationships can be reconstructed from narrative scenes of cooperation or confrontation, allowing for the creation of tentative agent 'biographies' that hint at their stories (Knobloch 2010, 2016, 2018) (Figure 2).

Reconstructing networks of Middle Horizon agents

Knobloch (2002) has created an open access, online database presenting an inventory of Middle Horizon human images that continues to be updated. Each agent is defined by physical attributes and accessories, such as tunics and shields, and then assigned a number (Figure 3). Facial elements include painted or tattooed designs, earspools, labrets, nose plugs, ear piercings and hairstyles. Headgear includes headbands, various caps, four-cornered hats with points or tassels at each corner, a conical hat with horns, a feline pelt with its head atop the agent's forehead, a 'top hat' form with vertical feathers, cowl-shaped hoods, and caps adorned with silver sequins (Knobloch 2010, 2012, 2018).

To conduct our SNA, 56 agents with well-defined identities were selected from Knobloch's online database. As documented in the database, 54 come from 33 provenances listed with each agent under the heading 'References'; 36 of these agents occur on artefacts alongside other agents (see Tables S1 and S2 in the online supplementary material (OSM)). Some artefacts come from specific locations, such as excavated sites, while others have only general locations, such as a particular river valley. Due to these limitations, we have chosen a presence/absence methodology that focuses on two questions: a) based on the presence of the same agents, which locations have more similarities? and b) among agents, which have more similar associations based on their presence together on the same artefacts?

To address these questions, Gibbon constructed two networks. The first is an agent-location network, where the nodes are the locations. The links connect locations that feature the same agent, based on the Jaccard similarity coefficient, where the shared presence of a similar suite of agents results in increased similarity (Figure 4). The second is an agent-agent network, where the nodes are agents, and the links are artefacts that feature the shared presence of one or more agents. The Jaccard coefficient is the most appropriate similarity coefficient to use for the presence/absence of archaeological data because it is not affected by the shared absence of a particular trait and therefore reduces the sampling error inherent in datasets that do not contain a representative sample (Habiba *et al.* 2018). Higher Jaccard coefficient scores indicate greater similarities between nodes that are represented by giving greater weight to links (Peeples & Roberts 2013). This allows for the strength of connections between locations/agents to be included in network analysis and visualisation. Links are undirected, meaning that interactions are considered to be symmetrical or equal. Undirected links are used in this study, as the direction of interaction cannot be determined definitively.

Figure 2. Tapestry fragment hinting at stories about agents. Ten agents are depicted in a confrontational pose, with two large, mythical avian figures grasping Agents 100 (left) and 101 (right) by their topknots. Top row (left to right): Agents 102, 106, 158, 103, 112 and 101; middle row under feet: Agent 100 and 108; bottom row: Agents 128 and 129. Agent 100 is also shown at the wing of the left avian figure. Site E, Ocucaje, Ica Valley, Peru, dating to Middle Horizon 1B or 2A (Menzel 1977: fig. 130) (courtesy of the Phoebe Apperson Hearst Museum of Anthropology and Regents of the University of California Berkeley, 4-4556 (actual size: 0.925 × 0.520m)).

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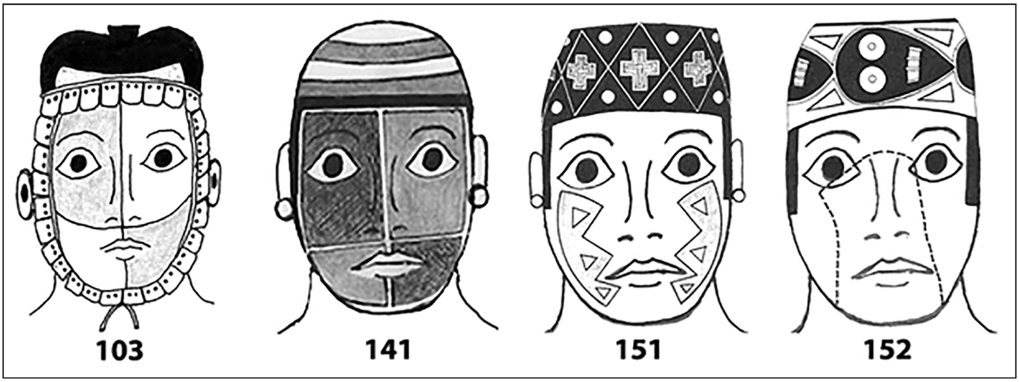

Figure 3. Examples of features used to distinguish agent identities (with Agent number), such as headgear, ear plugs and facial painting. Agent 152's incomplete face (due to missing sherds) is reconstituted within the dashed line (illustrations by P. Knobloch).

The size of nodes in the agent-location network indicates the centrality of their network position (eigencentrality), showing the connectivity of a location to other locations in the network. Larger nodes indicate greater connectivity. Likewise, the larger the node in the agent-agent network, the more often that agent is associated with other agents, based on their presence on the same artefacts. The colours in the models reflect clusters of locations or agents that share more similarity with each other than with other clusters, as determined by the Louvain community detection algorithm (Blondel *et al.* 2008). Widely used in SNA, this algorithm is similar to cluster analysis, which is commonly used in archaeology.

Analysing the agent networks

As Figure 4 illustrates, the critical features of a network can be obscured by many weak, often inconsequential, links. Therefore, three methods to elucidate the network's most critical relationships are applied: clustering coefficient, node deletion and link deletion (Barabási 2013). The clustering coefficient indicates how strongly nodes cluster together in a network as a measurement of the degree of interconnectedness between nodes. Tightly knit cliques are common in social networks (Watts & Strogartz 1998) and are often correlated with similarity measures.

Link and node deletion are two related methods of deconstruction that identify a network's 'core'—the integral relationships that structure the network. Link deletion removes weaker ties systematically, based on the link weight, as measured by the Jaccard similarity coefficient. This allows for the removal of links between sites or agents that share only a limited number of identical agents. In this analysis, the removal process is repeated at 20 per cent intervals until all links shared by nodes are removed and the network collapses into unconnected components (Figures 4B & 4D show the beginning of this process). By removing the 'weak links', those ties that are more integral to each of the Middle Horizon agent networks can more easily be identified.

The systematic removal of less-connected nodes is known as K-core deletion (Batagelj & Zaveršnik 2011). This method allows an analyst to set a minimum degree threshold (the

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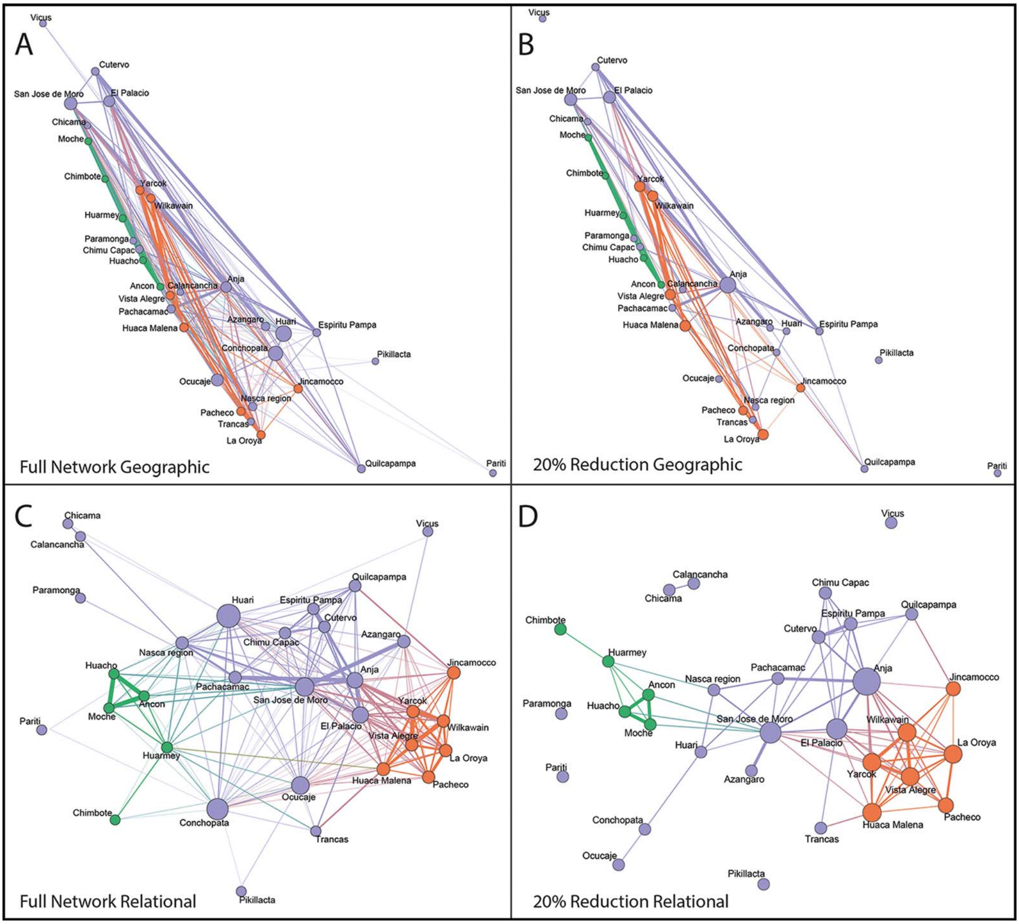

Figure 4. Geographic (A & B) and relational (C & D) layouts of the Middle Horizon agent-location network. Relational layout repositions nodes so that the most central and connected are toward the centre of the graph. The images on the left (A & C) show the full network, while those on the right (B & D) show the 20 per cent reduction that removes the weakest links from the network (figure by E. Gibbon).

number of links any given node has) for it to remain within a given network. In the agent-location model, for example, nodes were eliminated if they had fewer than two connections (K-core 2), followed by nodes with fewer than three connections (K-core 3). This process continued until nodes with fewer than 13 connections were eliminated (K-core 13), at which point the removal of one more node would have resulted in network fragmentation (Figures 5A & 5B). Through node deletion, the most important hubs of a network are brought forward.

To complement this process, hub deletion was also conducted. In contrast to K-core deletion, hub deletion systematically removes the nodes with the largest number of connections to other locations. Hub deletion starts with the removal of the highest degree nodes in the network (in our case, those with 20 connections) and continues until the removal of nodes causes the network to collapse into multiple unconnected components (Figures 5C & 5D).

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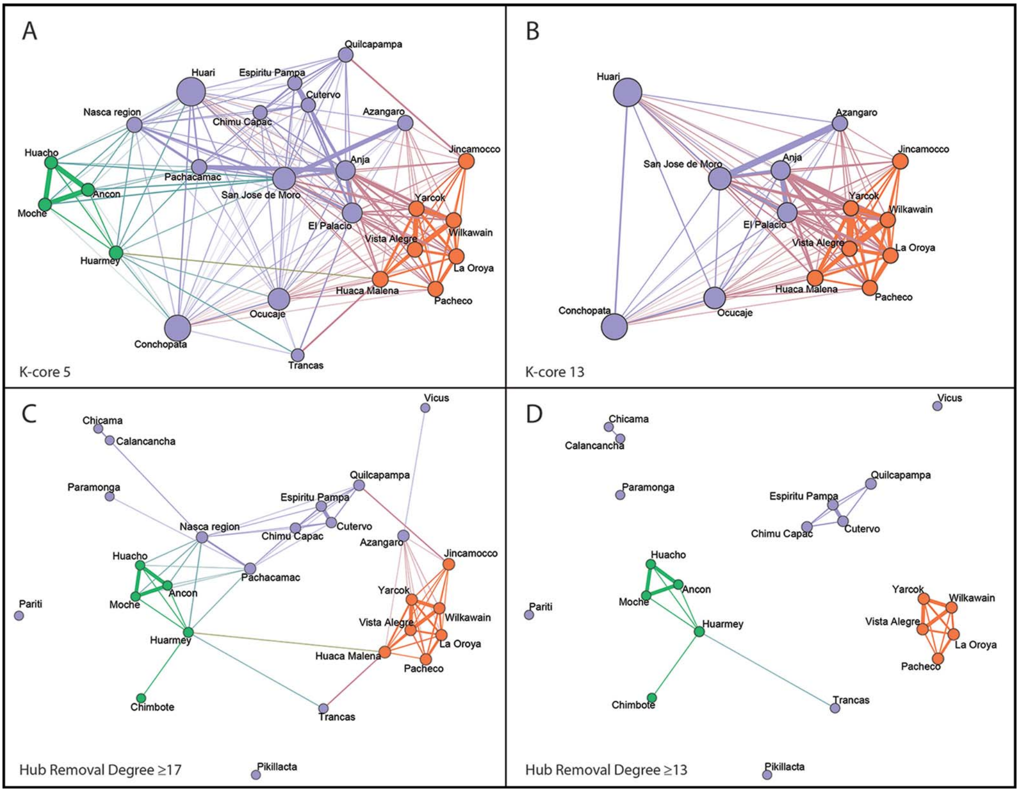

Figure 5. Examples of stress testing that helps to identify the most important nodes and links in the relational agent-location network: K-core tests that leave only the most connected hubs in place (K-core 5 shown in A and K-core 13 in B); complementary tests where high-degree hubs are successively removed from the network (to degree 17 shown in C and to degree 13 in D) (figure by E. Gibbon).

This process can be used as a test for network resilience and allows evaluation of the dependency of the network on central places.

To gather more information, other measures can be used to calculate the centrality of nodes from an original network and any of the networks created by node and link deletion (for centrality measures, see the glossary in Collar *et al.* 2015). We used degree, closeness, betweenness and eigenvector centrality measures to quantify individual node properties that may help to identify a location or agent's role within the overall network. Degree centrality is a measure of how many links a node has. Closeness centrality is the reciprocal of the shortest paths between a node and all other nodes in the network—a more 'central' node is closer to other nodes. Betweenness centrality is a measure of the shortest paths between each node in a network that pass through a node. Eigenvector centrality is a measure of a node's influence on the network, as calculated by the degree centralities of its connections—Google's 'PageRank', for example, uses this measure of centrality.

Clustering, deletion and centrality measures characterise networks, but we also need to ensure that these are meaningful patterns and not a function of chance. One thousand randomly generated networks were created with the same number of nodes and links in order to

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approximate a null model (Butts 2008; Gjesfjeld & Phillips 2013). Mann-Whitney U-tests were then applied to compare the centrality measures of each of the networks with the corresponding null model to determine the statistical significance of any observed patterns in the archaeological data (see Table S3 in the OSM). The Mann-Whitney U-test was selected because it permits two independent samples to be compared without assuming a normal distribution. The statistical tests summarised in Table S3 suggest that the clustering and centrality observed in the archaeological networks were not due to chance.

Comparison of the archaeological networks with randomly generated networks, combined with node and edge deletion tests, also allows for an overall evaluation of the robustness of the archaeological data. The patterns and results that consistently appear across each iteration of the networks are unlikely to be altered significantly by the inclusion of new data, even if the details of the networks change, as inevitably they will with future discoveries.

Discussion

Connecting the depictions of agents to past political activities is not straightforward. The identities and sequencing of agents through time is subject to debate; how they interacted is unclear; and some relationships were probably left undepicted. Nonetheless, we contend that the Middle Horizon artists used the agents to reference Wari contacts and political interactions, and SNA provides insights into the relationships that shaped the era.

The social networks generated are resistant to node and edge deletion; they do not quickly fragment into smaller networks as nodes and links are removed. This suggests that the suite of Wari agents was well-known across the Central Andes. The agent-location and agent-agent networks also show significant clustering—that is, the same agents are often found displayed together on artefacts in the same regions (Table S3). This, in turn, suggests that artefacts in clay, metal, cloth and other media used the same iconographic grammar to represent regionally important agents and that these shared elements reveal an understanding of historic encounters.

The networks are weakly centralised, meaning that there was no central location or agent (such as a single Wari ruler) through which all locations and agents, respectively, were connected. Put simply, our SNA suggests that the Wari state was heterarchical. Two aspects of the agent-location networks emphasise this point. First, Huari, the largest city in the Wari state, is not the primary node in the 20 per cent similarity threshold agent-location network (Figure 4B & D). The site is connected more strongly to certain communities than others, and centrality measures suggest that it was not overly important to them. Second, the site's middle-range eigenvector in the 20 per cent similarity threshold network indicates that its centrality in the full network is based on weak ties to many sites. The hub deletion tests also show that the removal of Huari from the full network does not cause it to fragment into unconnected components. These results suggest that Huari was neither the source of some agent depictions, nor did it exercise control over where agent depictions were found.

The network's heterarchical structure, with weakly centralised clusters, is also clear in the agent-agent network (Figure 6), where deletions reveal an underlying 'core' structure that resists further segmentation due to multiple strong relationships across clusters. The overall network is resilient to node and edge deletion due to the existence of a few well-connected

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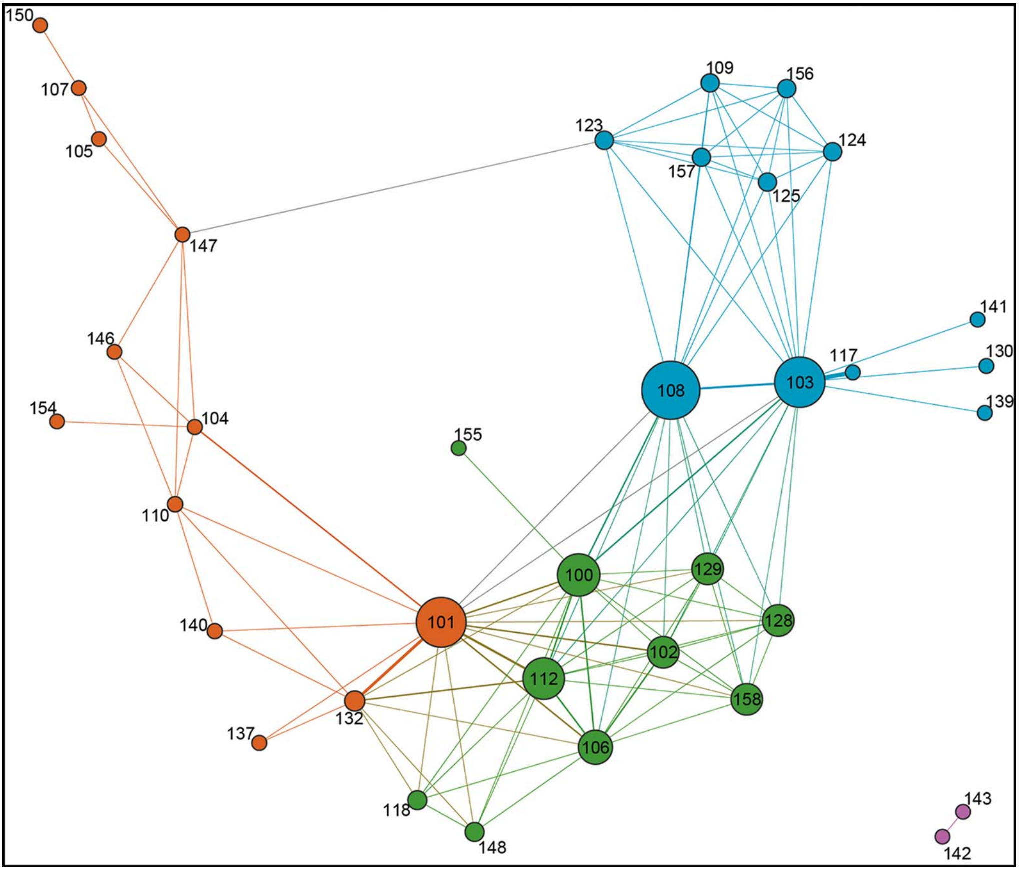

Figure 6. Relational view of the Middle Horizon agent-agent database (figure by E. Gibbon).

nodes, such as Agents 101 and 103 (both depicted in the tapestry fragment illustrated in Figure 2). These agents appear to have served as important contacts between agents. Further excavations at Huari will undoubtedly reveal more agents, but the network's basic structure is unlikely to change significantly.

More specific aspects of Wari's expansion and political structure can be detected. After node and edge deletion, Figure 4B shows a green cluster on the north coast and an orange cluster dominating in much of the southern half of the network. The purple cluster is diffused across the network. Regional clusters make sense—some of the agents probably represent ethnic groups—but there may also be temporal dimensions that reflect the activities of different generations, or even stages, of Wari expansion.

The agent-location network also reveals the geographical corridors that connect regions such as the Wari heartland to coastal Nasca and, further north, Cajamarca to Jequetepeque. The higher eigenvector centrality of sites such as San José del Moro in these corridors underlines their important roles in disseminating agent depictions, as already revealed by research documenting an influx of Wari colonists and objects through these corridors (Watanabe 2016; Conlee 2021).

The agent-agent network provides additional understanding of Middle Horizon political relationships. We know which agents tended to interact the most and bridge clusters (such as Agents 100, 101, 103, 108, 109 and 112). These characteristics can then be paired with more qualitative observations of the 'agency' in the depictions, for example, of fighting, captivity, or worship. Based on these qualitative observations, we can then return to the agent-location networks to add further details about the individual agents.

Qualitative observations, for example, suggest that agents may have been divided into religious factions (Knobloch 2018). One faction favoured the Altiplano Staff God and secondary Profile Deities (so named because they are represented in profile), as seen on the Gateway to the Sun at Tiwanaku, in Bolivia. Another faction followed certain Profile Deities that may represent the deities of ethnic groups within the Wari realm (Isbell & Knobloch 2009). Thus, Wari's state religion may not have supported a hierarchical structure with a single divine authority, but rather, catered to a heterarchical community of deities. The agent-location and agent-agent networks may map onto some of these religious factions, and suggest areas of further research in Middle Horizon belief systems.

In a more specific example, qualitative agent analysis of images on ceramic and metal artefacts from Espíritu Pampa suggest that the site was located in Agent 103's heartland (Knobloch 2016). The SNA provides us with an understanding of Espíritu Pampa and Agent 103's position within Middle Horizon networks that is not tied to previous interpretations of the site and the agent's role in the period. Our agent-location analysis suggests that Espíritu Pampa's leaders had a well-developed network of contacts that, for the most part, bypassed Huari and who may have commanded equal status in the Wari hegemony. In a similar manner, the agent-agent network illustrates Agent 103's wide social network. Taken together, the SNA data support Knobloch's suggestion that Agent 103 was a powerful, and at times independent, player in Middle Horizon politics.

Conclusion

Over the last 50 years, early models of the state derived from late nineteenth-century cultural evolutionary theory have come under scrutiny. Few would now argue for early states led by all-powerful rulers, with well-oiled bureaucracies and an unencumbered reach. After all, the early cultural evolutionists themselves were aware that their general conceptualisations neglected the complexities of specific states (e.g. Morgan 1878). Today, there is greater acceptance that the earliest states were more 'heterarchical', yet we still struggle to find tools to better understand the relationships that structure the earliest state-like polities. Here we have argued that SNA of state-associated iconography can provide valuable information about a polity's expansion and political organisation.

In the 1960s and 1970s, Wari was seen as an all-powerful, monolithic state that conquered and controlled a broad swathe of the Andes (Menzel 1968; Lumbreras 1974). Recent research has questioned the state's reach and political structure (e.g. Jennings 2010; Makowski 2016), and the decentralised, highly clustered and resilient networks revealed in our study support a consideration of the more heterarchical aspects of the Middle Horizon Wari polity. Future research combining SNA with other datasets will, we believe, bring into sharper focus the development of the earliest states in the Central Andes and beyond.

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Supplementary material

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