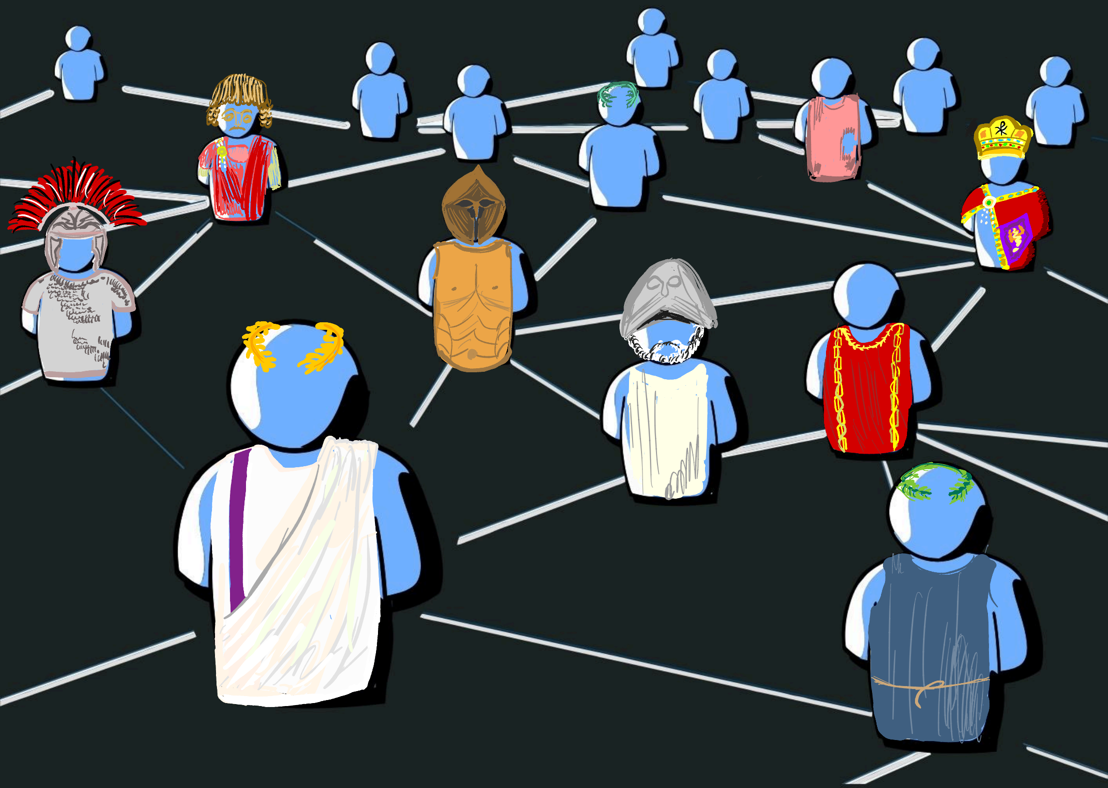
Journal of Historical Network Research

4 | 2020
special issue



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THE TIES THAT BIND
ANCIENT POLITICS AND NETWORK ANALYSIS

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JHNR

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Athens as a Small World

Journal of Historical Network Research 4 (2020) 36-56

Keywords

Athens; betweenness; biographies; ego-networks; Pericles; women; small world

Abstract

Athenian political life in the 460's and 450's BC centered on conflict between the Oligoi and the Demos, whose positions were articulated by Cimon and Pericles, and then Cimon's successor, Thucydides son of Melesias. Through the building program debate in the ecclesia, and the success of Pericles over his opponent who was ostracized, the fissure between clusters was resolved, and the Demos got the upper hand. In 1998, Anthony Podlecki wrote a book called *Perikles and his Circle*, and before that Philip Stadter (1991) wrote an influential article entitled "Pericles Among the Intellectuals." To their work, we now add an example of formal social network analysis to study the position of Pericles in the social network of intellectuals, artists, politicians, and cultural creatives in the mid-5th century BC. The study shows clusters of varying size and relative positions in which boundaries were fluid and there was much interaction. Women feature highly in betweenness centrality. The data set includes 328 nodes, and 754 edges, built around the ego-network of Socrates, of which Pericles, political figures, and the intellectuals are members. The data consists of an edge list drawn from all of Plato, Plutarch's lives of Cimon, Pericles, Nicias, and Alcibiades, plus Xenophon's Memorabilia and Symposium, as well as Lysias's speeches and some of Diogenes Laertius Book 2 on Socrates.

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Since 2010, I have experimented with historical networks in Athens and in the lives of Alexander the Great and Socrates by turning to social network analysis (SNA).[1] SNA focuses on patterns of relations among groups of actors. It seeks to uncover their relationships and explore interconnections.[2] This includes observing the structure of the network, looking at cohesion, small world effects, and structural holes. SNA can uncover the key players in the network, often revealing network patterns that influence the reception or rejection of ideas, innovations, and attitudes. SNA allows us to see the structure of the network as a whole and understand the constraints and opportunities based on one's position inside the network. One reason to study social networks is to understand the paths for diffusion of ideas. Athens has always been characterized as a creative, innovative place, where people experimented in their own crafts, with forms of writing and literature, with institutions and political ideas, with evolving forms of making laws and with opportunities for people to participate in public life. It is known for being a remarkably permissive society where, as Pericles (Thucydides) puts it, "There is no exclusiveness in our public life, and in our private business we are tolerant of each other nor do we get into a quarrel with our neighbor when he does what he likes" (2.37.2).

What conditions enabled Athens to achieve such success? I argue here that the creativity and innovation that we see in certain periods and places was enabled by social networks of the type classified as a small world network.[3] Some networks have nodes that are relatively evenly connected, each having the same number of ties, connected only to neighbours, and therefore unable to reach a node across the network without going through many intermediaries, like loops on a crochet hook. Other networks have many ties across the network, but they lead to disconnected nodes which do not have physical or relational proximity. These networks are inefficient. Yet other networks are over-connected and highly dense, like a ball of yarn, that makes cascades of

* **Acknowledgements**: I wish to acknowledge financial support from George Washington University and from the Andrew H. Mellon foundation for their grant entitled "Resilient Networks to Support Inclusive Digital Humanities". As a 2018-19 U.S. Fulbright Scholar to Greece at the University of Crete, Rethymno I received valuable feedback from colleagues and students. I thank my research assistant, Peri Buch. I also appreciate the support of Marc A. Smith at the Social Media Research Foundation and the software they developed which is used throughout, NodeXL. See Hansen et al. (2011).
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1 Cline (2012); Cline et al. (2015); Cline (2018), Cline (2019); Cline et al. (2019).

2 Hansen et al. (2011), p. 3-4.

3 Watts and Strogatz coined the term in 1998 for this particular type of network; Watts et al. (1998).

information more difficult. Small world networks are most conducive to sustained knowledge diffusion due to their short path lengths and high local density or clustering.

One might ask, weren't all ancient city-states essentially small world social networks? If we had more written evidence, we might be able to agree. What might have made the social networks in mid-fifth century Athens more innovative and open to new ideas were the democratic institutions which enabled people to randomly meet people outside their local circles, and come to know each other while serving on a jury, or walking to the Pnyx for an assembly, or asking for help writing a name on a sherd for ostracism, or parading in festivals. As Paul Cartledge sees it, democracy was a primarily Athenian phenomenon, and one chiefly to be associated with the classical world: "ancient Greek democracy, like any other *politeia*, was a total social phenomenon, a culture and not merely an institutionalised political system (as we would understand that)".[4] The Athenians had over two hundred festival days which gave them the leisure time to mix in relaxed settings and meet people outside of their local clusters of families and neighbours. Vlassopoulos, in challenging elitist views on class and status, noted the fluidity in Athenian culture: "I want to argue that the distinction between citizens, metics and slaves was often difficult to establish in Athens; that this was connected to the functions of Athenian democracy; that citizens, metics and slaves formed mixed and interacting cultures in collaboration and conflict; and that these interactions were created and enabled by what I will call free spaces."[5] I believe the fluidity of exchanges and structured opportunities for mixing in the democracy broke up the homophily which might naturally occur inside the city-states, allowing for small world networks to permit cascades of information and reach emergence.[6]

To understand how Athens became Athens, we can look to the social networks, understanding that any models we build, of course, are impaired by the incompleteness and bias of our sources, the difficulty in including people in social network diagrams whose names we do not know, the dynamism of social relations which cannot be captured in a static diagram, and the myriad other reasons we could find which should persuade us not to try. In experiments we examine the necessary small world characteristics we would expect to find in

4 Cartledge (2009), p. 57.
5 Vlassopoulos (2007), p. 33.
6 Cline (2018).

eISSN 2535-8863 *Journal of Historical Network Research*
DOI: 10.25517/jhnr.v4i0.84 No. 4 • 2020 • 36-56

small world networks: a relatively low average path length and high clustering compared to a random network with the same number of nodes.[7]

A challenging aspect of using SNA to study individuals in ancient history is finding a subject with enough ancient sources from which names may be extracted. An ego-network is the analysis of an individual person, institution, or even a state. Usually we study the relationships between the ego and its "alters", the other nodes in the network around the subject, but one degree (one step) of separation is insufficient. To build out who knows who, modern sociologists would interview the people whom the ego and everyone in the network had named; for antiquity, we rely on written sources and do what we can to collect enough relationships to be able to analyse the network and roles within it.[8] Finding enough raw data is less of a problem in archaeology, where one might study the origin and diffusion of sculptural styles, or pottery production, or brick marks which spread from a center to other areas through trade.[9]

For studying networks of historical figures in Greece, the nature of the evidence depends on later authors, or inscriptions. There must be enough evidence to build the edge-list, the two columns with names of people with ties between them. For example, at first glance one might imagine that a good data set might be the manumission decrees inscribed at Delphi, with so many personal names. Unfortunately, the names and dates do not overlap enough. The people named are not members of a social network; that is, they did not know each other or have people in common. That they all left a record on the retaining walls of the Temple of Apollo is not enough to call it a network. Furthermore, the range of dates is too broad. Dead people do not belong in a social network. Biographies of the length of Plutarch's Lives usually only provide one or two degrees of separation, which is not terribly informative. In Rome, the number of texts to use as data for building an ego-network is larger

7 Humphries et al. (2008), Barmpoutis et al. (2010), Easley et al. (2010) p. 537-565, Teleford et al. (2011), Zaidi (2013).

8 Crossley et al. (2015) is the first handbook focused on ego-networks, which looks at individual relationships in a community and how they overlap with each other. See p. 1-43 for a starting place to understand the study of ego-networks. Other resources for ego-networks as a subset of SNA include Prell (2012), p. 118-133 with excellent bibliography.

9 Graham (2006) and Knappett (2013) are good examples; see also the review article by Brughmans (2013) of social network analysis primarily as used in classical archaeology with examples from the Neolithic through Roman times but referencing new world excavations as well. He explains basic terminology and briefly shows the breadth of topics explored through this method, including the diffusion of artifacts and ideas via maritime trade patterns, for which see Leidwanger et al. (2014). Brughmans et al. (2016) bring together some of the latest thinking on archaeology and network analysis, for which see also Lemercier (2015) and Mills (2017).

and possibly more fruitful than in Greek history. This is to say that SNA is not necessarily going to work unless one is confident that the nodes have some sort of tie with other nodes in the data.

In our case, these relationships are based in narratives which situate people in their social contexts, from which we are able to extract names and determine that ties between them exist. For demonstration purposes we will now study the combined social networks of Cimon, Pericles, Nicias, and Alcibiades from the biographies in Plutarch's *Lives.*

Because Plutarch's work is biographical, it naturally makes Pericles the center of the social network, the "ego", represented as nodes on the graph. Some people who know him also know each other, called triadic closure. Family members of Pericles, for example, are connected to each other in this way. But there are many nodes connected to Pericles and no others. On the graph, they appear to be lonely, only knowing the ego, Pericles. Of course, in reality they had their own lively close circle of friends and family who are not featured in our texts. Each of these singletons are visual reminders that our data is incomplete. We must also bear in mind that on average, in the modern world, the sum of close and weak ties that people have ranges from 100 to 5,000, if we include the people we know by name.[10] The ego-network of Pericles derived from Plutarch's *Life* (Fig. 1) has only 54 people (nodes) with 79 ties (edges) connecting them to each other.

Here we see a graph of Pericles's social network that is based only on the names found in Plutarch's *Life of Pericles*. At first glance it gives a rather limited view of his social world and does not reveal patterns we would not know from reading the text. In this graph (Figure 1) we see his personal and professional ties in clusters of which the predominant ones are the educators he knew as a youth, his rival Cimon's family, and lots of single individuals. We have a multiplex network, which means it includes different kinds of ties, such as family members, friends, people who fought together, served as generals together, met on the street and conversed, or socialized.[11] There are a few more perspectives that SNA can provide, though.

10 Kadushin (2012), p. 34, 108-119, 208.
11 Hobden (2013), p. 195-246.

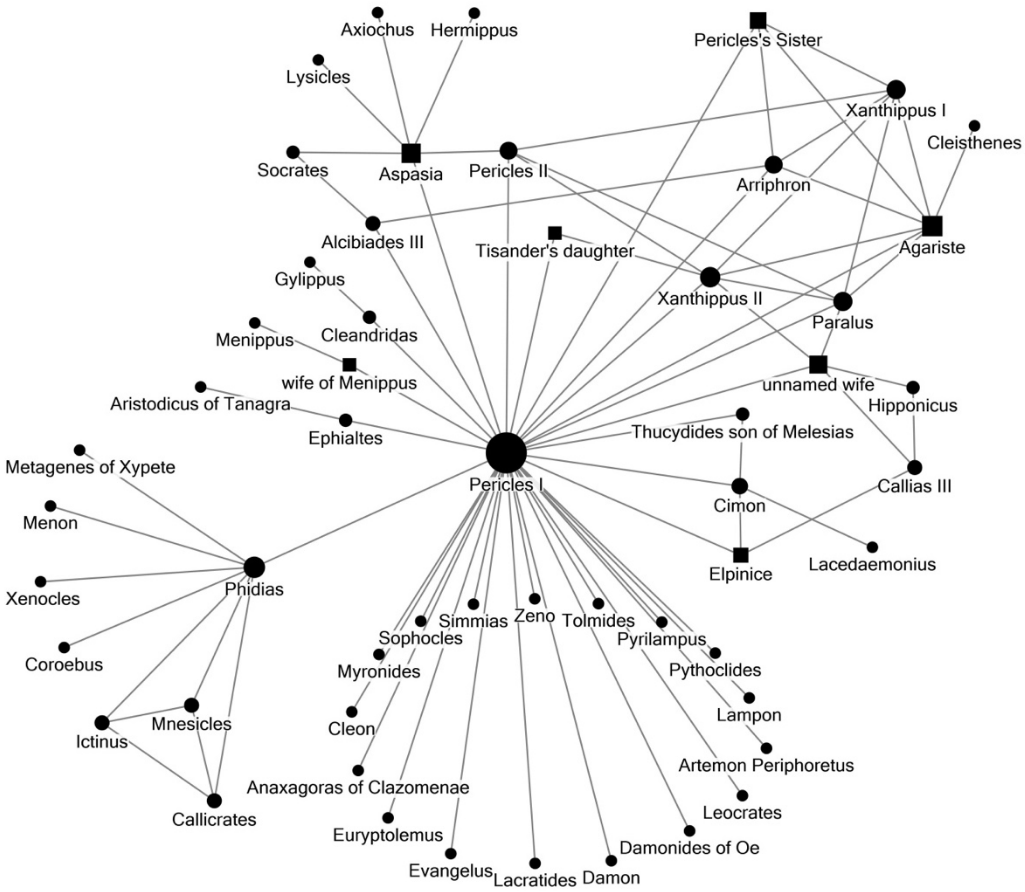

Fig. 1: The social network of Pericles in the mid-fifth century BC in Athens based on Plutarch's *Life of Pericles*. Women are represented by square nodes; men are disks.[12]

First, if we group the nodes by sex, we have men and women in the network, as seen in figure 1 by squares for women and disks for men. In Figure 2, the women's ties are represented in red. Here we observe that the women are located in the area of Pericles's family, and with the exception of Aspasia, stay mainly linked to immediate family members and the families into which they

12 All network diagrams were generated using NodeXL (Smith, M., Milic-Frayling, N., Shneiderman, B., Mendes Rodrigues, E., Leskovec, J., Dunne, C., [2010], NodeXL: a free and open network overview, discovery and exploration add-in for Excel 2007/2010, http://nodexl.codeplex.com [accessed on February 8, 2017] from the Social Media Research Foundation.

married. Two have unknown names, Pericles's sister and his wife. The traditional interpretation is that writers and orators avoided naming women while they were living, and as a result, their names were lost to future writers.[13] This may not be exactly true, since many women made dedications under their own names, and were sometimes inscribed in Athenian inventory lists of temple treasures.[14]

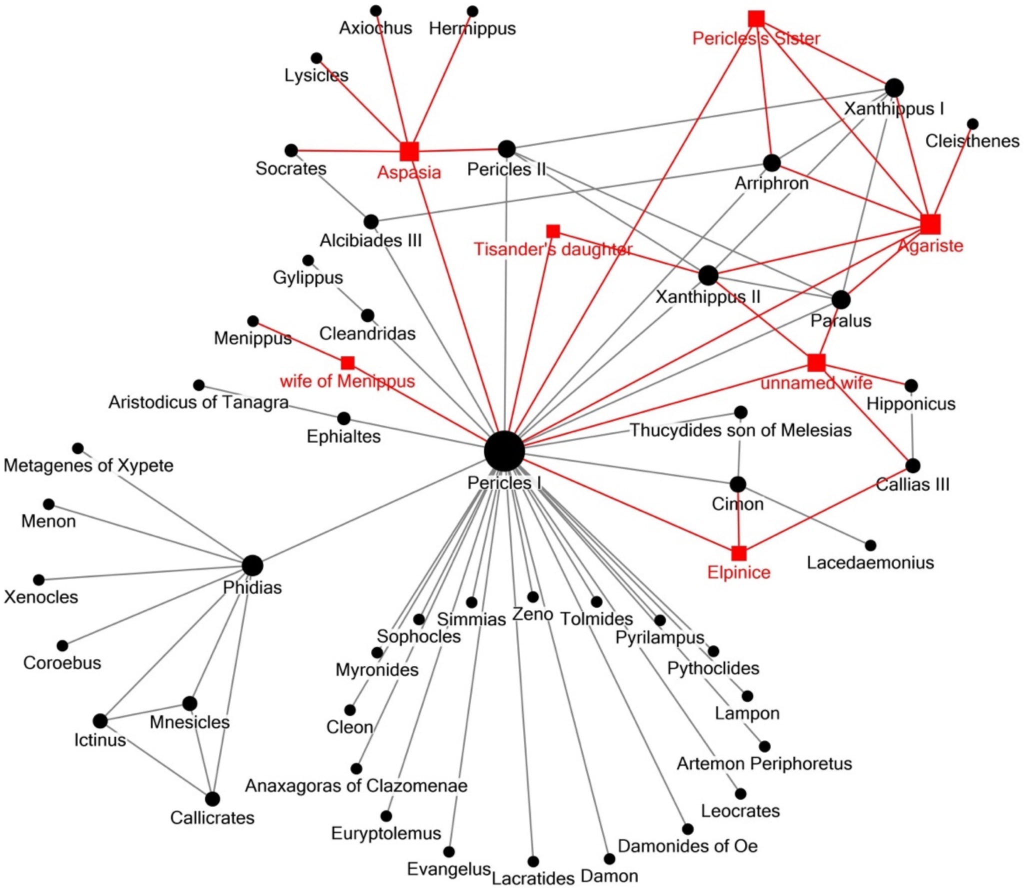

Fig. 2: The women in Pericles's network, in red squares

13 Bremmer (1981).

14 Harris (1995), p. 237.

The most highly connected node after Pericles (34 ties) is Phidias (8), who is the only node connecting the seven named workmen on the building programme to the rest of the network. It is likely that they knew each other, it is possible they all knew Pericles personally, and they may have known others socially or professionally, but Plutarch doesn't mention any of this, so these potential ties are excluded here. Following Pericles and Phidias in degree centrality (number of ties) are Pericles's family members: his father Xanthippus I (6), his sons, Xanthippus II (7) and Paralus (6), as well as the women: Agariste his mother (7), his unnamed wife (5), Pericles's partner later in life, Aspasia (6), and Pericles's unnamed sister (4). Elpinice, his rival Cimon's sister, has three ties; Cimon has four. There are eight clusters inside the social network, indicating that Pericles, while obviously the largest, is not the only hub in a chart of spokes, but the others know each other in a variety of ways.

Betweenness centrality measures how central individuals are within the fabric of the social network, by measuring the path lengths that would flow through this person relative to everyone else. We might expect women to have a high betweenness centrality measure because they link families together through marriage and are often mentioned in the contexts of their parents, spouse, sometimes lovers, and children. In Figure 3, we see the ten highest betweenness centrality scores for the social network of Pericles, sorted highest to lowest. Five of the top ten are women. Aspasia, Agariste, and the unnamed wife come in third, fourth, and fifth. This measurement is not dependent on the number of ties, but on the position in the network. Looking at social networks by gender could be a useful preliminary step to study the roles of women in ancient history from other texts or periods.

Can this little social network, with just 54 nodes and 79 edges, be called a small world network? If we look at the numbers, we can say yes. The maximum number of hops along the path connecting any two nodes is 4, but the average is 2.5. This means a few well connected nodes across the network help less connected ones take short-cuts, as can be seen in Figure 4. In addition, a small world network needs a higher than random clustering coefficient. This means that the social network consists of many cases where someone's friends also know each other; that is, they are mutual friends. This is where ancient texts can let us down. We are almost sure three people know each other, because one is friends with both, but we cannot be sure we can close the triangle confidently. High clustering can be measured in several ways, by looking at the local clustering for each individual and making an average, or by dividing how many ties there are in the network (the number of edges) by the maximum number of ties there could potentially be in the network, called the graph density. In this case, the score for the average local clustering coefficient is 0.225, and the graph density is 0.055. As both of these scores are higher than a random graph, and we have a low average path length, we can call it a small world network. We will compare these numbers as we grow the graphs for mid-fifth century Athens.

Node	Betweenness Centrality
Pericles I	1254.500
Phidias	340.000
Aspasia	176.833
unnamed wife	75.250
Agariste	59.333
Cimon	52.833
Ephialtes	52.000
wife of Menippus	52.000
Cleandridas	52.000
Elpinice	24.750

Fig. 3: Ten highest betweenness centrality scores in the social network based on Plutarch's *Life of Pericles*

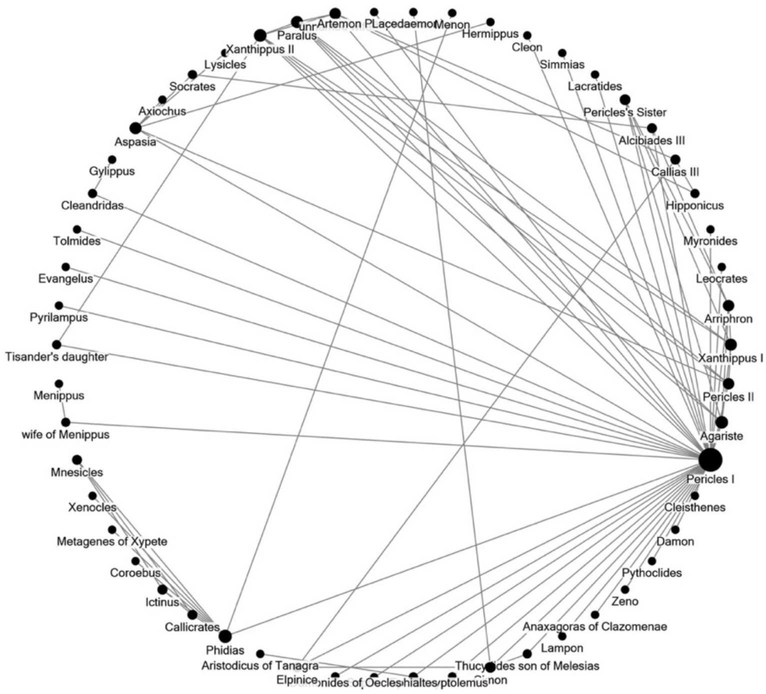

Fig. 4: The network from Plutarch's *Life of Pericles.*

The graph we produced from reading Plutarch's *Life of Pericles* (figure 1) is a fair representation of the names mentioned in Pericles's life, but is not full enough to give us insight into the political or personal relationships of the mid-fifth century BC. To build up this network and make it richer for study, we can add the names of the people mentioned in other sources, such as Plutarch's *Life of Alcibiades*. This also extends the timespan we are examining down into the end of the fifth century. The result is a network with 106 nodes and 145 edges connecting them (Figure 5). The network has 11 clusters, well beyond the two major hubs, Pericles and Alcibiades.

Alcibiades lived with Pericles's family while growing up, because his father had died. Thus, we expect that they would know many of the same people. But when combined, the resulting graph is surprising (Figure 5). One might have assumed that their social networks would have much overlap, but apart from family members, there are not a lot of shared connections, as we can see in Figure 5, which is based only on combining the people mentioned in Plutarch's *Lives of Pericles* and *Alcibiades* (note that the ties to Pericles are shown in red). This in turn suggests that we might want to look more closely at Pericles and Alcibiades, along with their social circles. It also leads us to wonder why and examine who exactly they do share in common. The graphs help us target what to investigate and show us new problems or questions to ask. Why are Euryptolemus and Ariphron so prominent? Euryptolemus II is a cousin of Pericles and Ariphron is his brother, who was also responsible for their ward Alcibiades's upbringing. Other prominent intermediary figures include Callias III, Pericles's unnamed wife, and the Spartans Gylippus and Cleandridas, and even Socrates, who connects Alcibiades to Pericles through Aspasia.

There is an age difference; Pericles served as Alcibiades's guardian after his father died, but is there something generational, social, political, or personal going on that keeps them in such different social spheres? A feature of successful social networks is the ability to reach outside one's own cluster relatively easily and exploit the so-called "strength of weak ties".[15] In terms of the small worldness of this combined network, we find that the maximum path length is 5 (compared to 4 with Pericles alone), and the average path length is 2.7. The score for the average local clustering coefficient is 0.260, whereas for a random network with the same number of nodes, the clustering coefficient would only be 0.018, considerably lower. There are some high-degree nodes which enable the weaker nodes to access the network efficiently, another criterion for calling it a small world network.

15 Granovetter (1973).

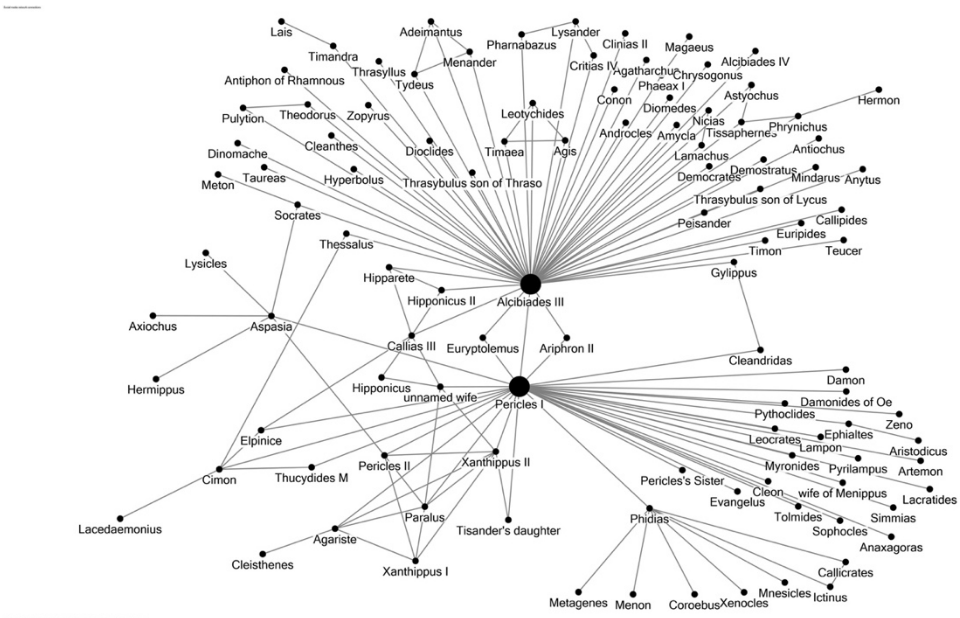

Fig. 5: A network of the people in Plutarch's *Lives of Alcibiades* and *Pericles.*

We might expand the network out further to enrich the context by adding the names and relationships mentioned in Plutarch's *Lives of Cimon* and *Nicias* as well (Figure 6). As we add pairs of names to the edge-list from these four texts, the richness of the data expands.

The four people with the largest number of ties are Pericles, Cimon, Nicias and Alcibiades, as we might expect because the sources for the relationships are drawn from their biographies in the four Plutarch's *Lives*. They have some people in common and Figure 6 shows how their networks intersect. It is also interesting to note how many women appear in this list; women tend to have high betweenness scores here as well because they are literally holding families together. Aspasia has her own cluster that includes Pericles, Socrates, Alcibiades, and more.

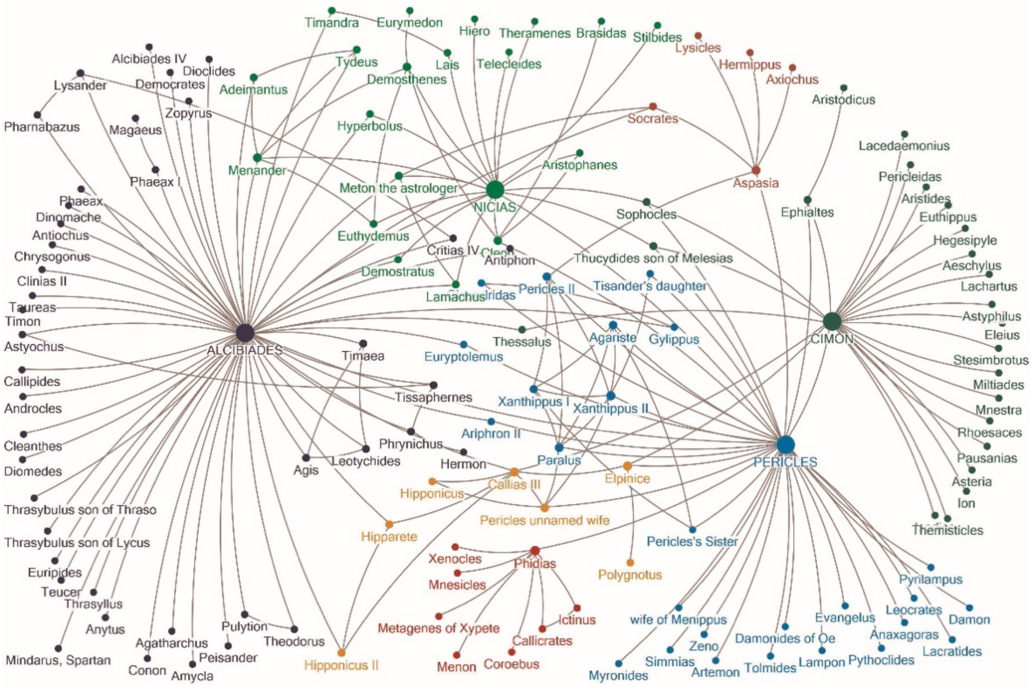

Fig. 6: The social networks of Pericles, Cimon, Nicias, and Alcibiades according to Plutarch

We can also see individuals in the middle of the graph who are brokers between the four main clusters. For example, clusters include the people around Pericles, Alcibiades, Cimon, and Nicias, but we also see independent clusters such as Phidias and his workmen, and some of Pericles's family members and their ties. Now this network has 133 people who have 191 ties between them. The maximum path length (also called geodesic distance or diameter) is 5, and the average path length is 2.92. The number of ties did not grow as much as might be expected when we added two more "Lives", because many of the additions were already members of the network in the first two "Lives". The maximum path length stayed the same, just under 3, while the average clustering coefficient is 0.252, about the same as 0.260 for just Pericles and Alcibiades. The graph density here is 0.021, where the former was 0.024. In other words, even as we scaled up by adding the networks of Nicias and Cimon, the characteristics of the network did not radically change. They all are small world networks.

As mentioned, SNA gives us statistics for measuring the strength of each individual's relationships and their particular role inside the network. So far, we have been measuring the network as a whole to determine whether it fit the small world network criteria. Let us examine the role of women by their betweenness centrality scores. When we studied the social network for Pericles alone, we found that five of the top ten were women. In Figure 7, we see a list of the highest betweenness centrality scores for this social network of 5th century Athens based on four of Plutarch's *Lives*. These scores are generated based on the pairs of relationships we entered. Out of 133 people, the top four are the egos of Plutarch's Lives. Phidias and Callias III are in fifth and sixth place, because Phidias is the link to all the craftsmen for the building program, without whom they would all separate from the main component. Callias III has a special place in the network because he links Pericles's unnamed wife, Alcibiades, and Cimon. Aspasia has the seventh highest score, Elpinice is in 10th place, Pericles's unnamed wife has dropped to 19th, Agariste and Pericles's unnamed sister are 26th and 27th. Why are women less important in linking clusters in the larger social network? Because the nature of the ties is so varied in this multiplex network, the men can be related through work, recreation, civic service, and more. In the small network with just Plutarch's *Life of Pericles*, familial relationships were the main way the graph changed from a hub with spokes to something more entangled.

Degree	Betweenness
Pericles I	Pericles I
Phidias	Phidias
Agariste	Aspasia
Xanthippus II	unnamed wife
Aspasia	Agariste
Paralus	Cimon
Xanthippus I	Elpinice
unnamed wife	Alcibiades III
Pericles II	Pericles II
Ariphron	Xanthippus II
Cimon	Paralus
Pericles's Sister	Ariphron
Elpinice	Pericles's Sister
Alcibiades III	Xanthippus I

Fig. 7: Highest degree and betweenness centrality scores in the mid-fifth century Athens social network

In the recent literature which uses network thinking to explain some aspects of ancient history, sometimes the term "small-world" is used metaphorically.[16] This is a technical term in network science for a certain kind of network that meets three criteria, and results in a connected society where information can flow quickly and one need not know everyone face-to face to take advantage of the collective; one need only be three hops away from who you need to meet or what you want to know.[17] Small-world networks enable innovation because new ideas and behaviours can pass through rapidly. A network has properties of a small world if it has the following: a small average path length, a demonstrated power law curve for degree centrality, and a clustering coefficient above random.[18]

The first measure that must be present is a relatively small average path length.[19] The length of the average path is an important measure of how efficient the network is as a whole, since it is directly correlated with how different parts of the network may communicate and exchange information. Such networks are characterized by a few actors knowing a lot of others, thus holding high degree centrality scores, and a whole lot of others who only have a couple of ties. A network only needs a few such people serving as hubs connecting people to make it a small world.

If we look at the metrics for the combined network as a whole, we learn that there are 133 actors or individuals in the social network we have constructed from these texts and 191 edges or ties between these individuals. The average path length between these actors is 2.92, consistent with the properties of a small-world network.[20] This means that on average it takes just three hops for one person to reach any other person within the network, because there are enough shortcuts across the network. In theory, if the many less well-connected actors can make it to one of these few more-connected people, it should be just one or two more hops from them to reach their ultimate target or destination, as we can see in Figure 8.

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16 E. g. Malkin (2011), Taylor et al. (2015).

17 For a discussion with bibliography of Athens as a face-to-face society, see Gottesman (2015), p. 44-76; Vlassopoulos (2007). For the path-length of three being common in small-world networks, see Kadushin (2012), p. 208-9. On benefits of small-world networks for diffusion, see Telesford et al. (2011).

18 This explanation of the criteria for small world networks is covered in more detail in Newman (2000), p. 819, Humphries et al. (2008); Newman (2010), p. 55-56, Borgatti et al. (2013), p. 259-261, Zaidi (2013) and Cline et al. (2015).

19 Newman (2000), Humphries et al. (2008), Newman (2010), p. 55-56, Telesford et al. (2011).

20 Newman (2000), p. 819.

The more short cuts there are across the circle, the smaller the world. While the familiar phrase “six degrees of separation” might seem to imply that an average path-length of six gives us a small world effect, that is for a hypothetical network of all people on the entire face of the planet, based on global experiments that would not be typical of an ancient city-state.[21] Today, because of social networks and the internet, the average path length is smaller than it was when Stanley Milgram did his experiment in 1967. Facebook research has recently determined that the average path length among the 1.59 billion Facebook users is just 3.57.[22] Inspired by Kevin Bacon, the IMDB (Internet Movie Data Base) also has an average path length of just 2.9 between 7.7 million actors as of January 2017.[23] Small networks like ours should also have a small average path length, and it does: 3.05.

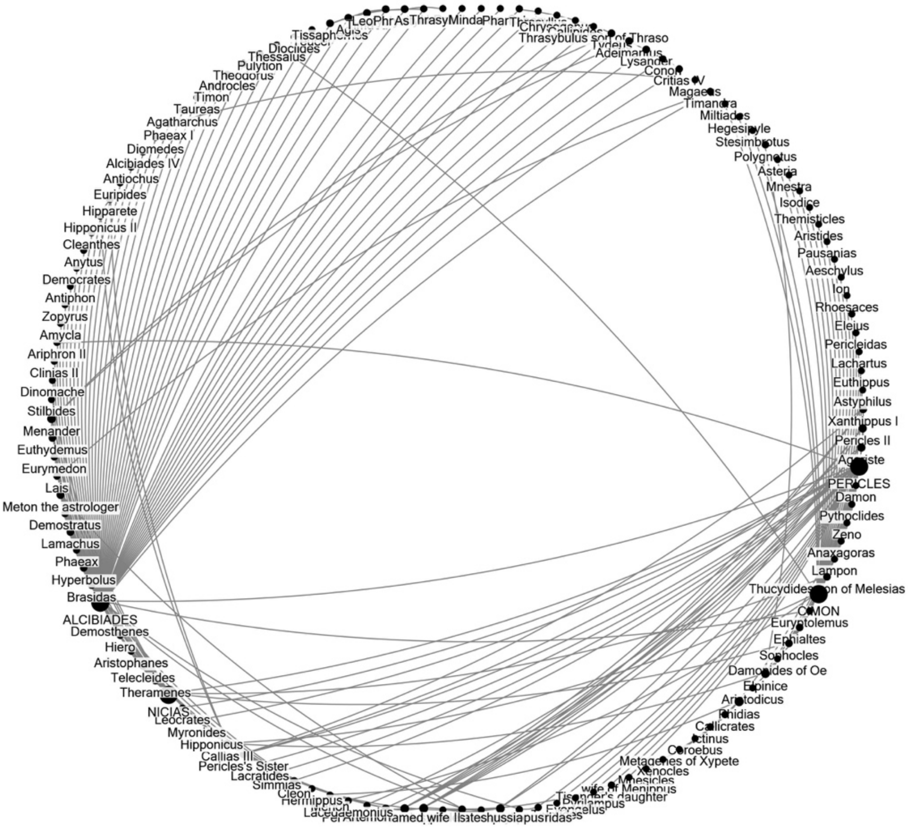


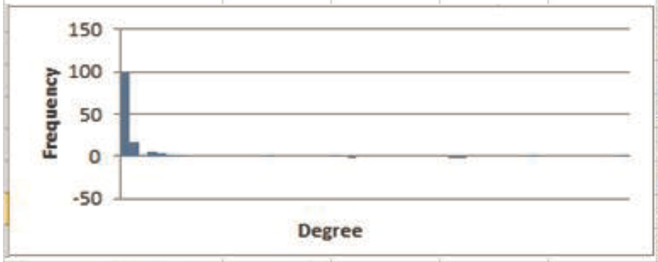
Fig. 8: The small world of Athens based on Plutarch’s *Lives of Pericles*, *Cimon*, *Nicias*, and *Alcibiades*

21 MILGRAM (1967), WATTS (2004), BARMPOUTIS et al. (2010).

22 BHAGAT et al. (2016).

23 EASLEY et al. (2010), p. 39-40; http://www.imdb.com/stats (accessed February 8, 2017).

In Figure 8 we see a few nodes along the bottom right side that have a lot of lines emanating from Pericles and Cimon, while on the left side Alcibiades and Nicias are dominant, and the middle section seems relatively sparse. Typically, in small-world networks, we find that there are a few people with a lot of ties and a whole lot of others with only a few or even just one connection to the network. This is called a power law distribution curve. To find the power law distribution, we ask, does everyone in the network have just about the same number of ties as everyone else or are there a few people who have many more relationships than others?



Minimum Degree	1
Maximum Degree	57
Average Degree	2.87218

Top Degree Scores:	
Alcibiades III	57
Pericles	35
Cimon	25
Nicias son of Niceratus	18
Phidias	8
Callias III	7
Xanthippus II	7
Aspasia	6
Menander	6
Paralus	6

Fig. 9: Power law distribution curve

This power law distribution curve is measurable and present in the Plutarch network. Recall that the network consists of 171 people. In Figure 9, we see that the maximum number of ties anyone has is 57 (Alcibiades), but the average is 2.87. This tells us that just a few people have a lot of ties, but most of the nodes are connected to only about two or three others. The people like Alcibiades, Pericles, Cimon, and Nicias are all examples from the head of the power law curve; they create the short cuts across the network that shortens the average path length. The majority of people, those with just a few contacts or only one, are all examples from the long tail. Thus, we have a small head and long tail in agreement with a power law distribution curve

Another property mentioned above that is present in all small-world networks is a high clustering coefficient that is greater than it would be in a random network.[24] Clustering coefficients are calculated based on how many triads (three people who all know each other) exist in the network. In a small-

24 ZAIDI (2013).

world social network, that number should be much higher than a random graph in which nodes are or are not tied together by a probability distribution.

One simple way to calculate the clustering coefficient of a random network to contrast with the Plutarch network is to use the formula C=2/N, where N is the number of nodes or actors present.[25] A random network with 133 individuals or nodes like ours would have a clustering coefficient of 0.015 (2 divided by 133). However, in our case, the clustering coefficient of the Athenian network is 0.252 (as calculated by the SNA program NodeXL and seen in figure 11), which is 17 times higher than it would be if it were simply a random network. This means it meets the definition of a network and is not a random assemblage of people.

In short, when writing about the ancient world using network thinking, it is easy to call a community a "small world", but to actually prove it is the challenge. Only networks that have short average path lengths, a power law curve for degree, and higher than random clustering coefficients may be called small world networks.[26] As we have seen, the world of Athens mapped from Plutarch's four *Lives* meets these criteria.

We started this experiment with Pericles and his social network. We added the social network of Alcibiades first, then added Cimon and Nicias, because they are roughly contemporaries with Pericles, and we wanted to broaden the network for context. Using Plutarch alone is problematic for reconstructing the social world of fifth-century Athens, and measures only the relationships of named elites, recorded over five hundred years after the fact. We are also missing the ties for each of the lesser-known people with their own ego-networks. The statistical metrics should not be viewed as fixed but relative. And there is the problem of the dates of Cimon through Alcibiades being combined in this way. There are surely other worries and anxieties about the method. But what else can we use? Classical studies have always suffered from a positivist fallacy problem.

In another experiment, I blended these four mid-fifth century biographies with Plato's Dialogues to mix in the social network of Socrates.[27] All together there are 302 nodes and 689 ties. Its maximum path length is 7, but the average is 2.9, giving it a short average path length. Socrates has 147 ties, but the average is just 4.55, so this network has a power law curve. The average clustering coefficient is .381, which means it has relatively high clustering, as 1.0 represents all the ties that could exist, and this network has about one-third of them. These

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25 Newman (2000), p. 819-820.

26 Watts (2004), p. 83-100.

27 Cline (2019) studies the social network of Socrates using only Plato, omitting Plutarch, Xenophon, Diogenes Laertius and other available sources.

are all good indicators that again we have social network with a small world phenomenon.

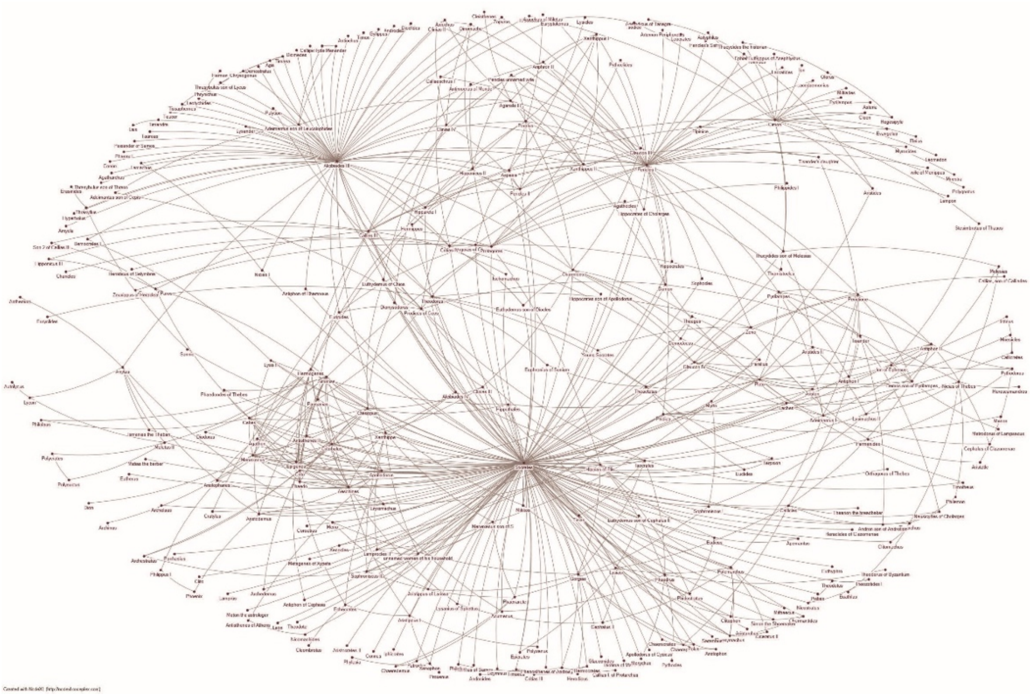

Fig. 10: The Social network of Socrates incorporating the four Lives of Plutarch and all of Plato's Dialogues

These network models are intended as a demonstration for future work in historical network research as applied to the ancient world. Social network analysis is a tool for discovery, a way to examine the fabric of ancient societies, given the limitations of our sources. For ego-networks, the technique allows us to see what cannot be retained by reading linearly: the focal person, who he or she knows, and who they know, over a span of hundreds of pages of text. The brokers, bridges, and leaders can be discovered based on statistics, and who are central and who are peripheral are revealed as well. Patterns and their anomalies dance off the page. Questions occur that would not have been raised by reading the texts in a linear way. For anyone who enjoys puzzling over relationships, be they personal ones or trade relations between city-states or colonization, or the relations between painters and potters, or religious networks, try this method just to see your data differently and discover new research agendas.[28] As a form of the digital humanities, social network analysis contributes to the expansion of the limits of what can be done in classical studies using quantitative methods.

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