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Network Theory and Religious Innovation

Anna Collar

Network theory recognizes that ideas and technology are transmitted along social interconnections, and cultural and religious change can be understood as emergent phenomena through analysis of the variability and dynamics of these interconnections. ‘Information cascade’ describes the diffusion of information across a network, providing, when combined with sociological theory of religious conversion, a way of re-approaching the success of the monotheistic ‘innovation’. Instead of viewing success as a measure of inherent merit, using networks means the observed outcomes need not be ‘superior’. This is in conflict with evolutionary theory, and this paper attempts to begin to reconcile these differing approaches.

Keywords: Network Theory; Cult Diffusion; Evolution

Introduction

The approach put forward in this paper, that of using network theory as a tool to analyse the social processes of religious innovation and conversion, arises from the uniformity observed in the dedications to the monotheistic Theos Hypsistos. Although intrinsic qualities can be argued to ‘explain’ a belief system’s attractiveness and diffusion, this method is incomplete, because it does not explain why some high-quality ideas fail. Combining some understanding of the ideology and utility of a religion with an analysis of the influences of social networks and environment allows a more subtle appraisal of the evidence. Ideas and technology are transmitted along social interconnections, and cultural and religious change can be understood as emergent phenomena through analysis of the variability and dynamics of these interconnections.
Network theory at a basic level allows the historian to visualize a node's degree of centrality or remoteness on a network; at a more complex level, it can help conceptualize the multifarious routes along which information travels. Theorizing networks takes the links between nodes and makes them as important as the nodes themselves for understanding the properties of social change. Its purpose is to explain how human interactions affect cultural change and influence the success and failure of innovations and ideas. Although the spread of monotheism in the Roman Empire was a long process, it is an idea that arises from small-world network theory, that of ‘information cascade’, which provides a useful way of re-approaching how and why the monotheistic ‘innovation’ was so successful across such a wide area.

Network Theory

There is a vast body of literature on network theory, especially in physics and sociology. What follows here is an overview of the key ideas: ‘phase transition’—the sudden dramatic shift from one network state to another; the small-world social network, made up of clusters interlocking with each other through weak and strong ties; the ‘short path-length’ property of the small-world network, which allows any two individuals to connect relatively easily; and the relationship of individual thresholds and network connectivity to the process of ‘information cascade’, as a result of these properties of the network.

Phase Transition

Mathematicians have long known that on a randomly connected network a ‘phase transition’ between disconnection and connection occurs—when the network is connected enough for most of the nodes to have joined up into clusters, with a few interconnecting links between the clusters—through the addition of a relatively small number of new links. The result is the joining of these isolated groups into one interconnected cluster, known as the ‘giant component’. The network undergoes a dramatic and sudden leap from one state to the other. Physical examples of phase transition include the magnetization of iron molecules, or the freezing of water. What the giant component does is allow communications across the whole network; i.e., when a network is not connected by the giant component, events are only felt locally. Absence of centrality is associated with phase transition and is vital to understanding the spread of information across networks. No single molecule causes a piece of iron to magnetize. It is a decentralized, emergent process.

Small events, behavioural switches, and individual choices percolate through the system and can lead to widespread change, and they could come from anywhere. Far from the centre determining the action on a network, the centre is created by that action. Watts states that ‘the network centrality of individuals, or any centrality for that matter, would tell us little or nothing about the outcome, because the centre emerges only as a consequence of the event itself’.
Small Worlds, Short Paths and Overlaps

But randomly connected graphs or networks are not representative of the real world. Social networks are by nature neither entirely regular nor entirely random: they are made up of close-knit (regular) clusters, formed by geography, religion, family and so on, intersected by long-distance (random) links, for example, somebody with whom nobody else in the cluster has any contact. This is the ‘small-world’ network. The long-distance connections transgress the boundaries of a local cluster, becoming shortcuts to other clusters in the network. It is a global network phenomenon that is couched in local network terms: the ‘small-world’ has a ‘short path–length’.

A short path in a social network can be either a ‘weak’ or ‘strong’ tie, where ‘strength’ and ‘weakness’ refer only to the fidelity of the connection. ‘Weak’ ties are low-fidelity bridges between different groups, representative of a long-distance or random contact. Converse to their name, Granovetter observed weak ties to be extremely powerful at facilitating diffusion across the network. This is because they cross network distance (the number of nodes one has to pass through to reach the desired node), directly accessing totally separate clusters or individuals, making them particularly useful for certain types of diffusion in social networks (for example, disease), or passing on information about new jobs.

However, most social ties are ‘strong’, reflective of fundamental facets of identity. Social identity can be defined (somewhat simplistically) by group membership. By belonging (or choosing not to belong) to certain groups, people acquire aspects of identity that drive the makeup of their social network. Most of these groups are clusters, ‘strong tie’ groups—trusted people, who may form ‘closed triads’ (the sociological term for a situation where all three people know each other)—or else have other markers of strength, such as frequency or length of contact. Socially, it is these people that exert the most influence on an individual when it comes to ‘complex’ transmission of ideas or information.

Mathematically, however, diffusion using strong ties poses a problem. The path length is long, that is, the information takes time to travel from one side of the network to the other, as it must make lots of little hops through the clusters. However, empirical social network data has shown that strong ties can still have a relatively short path length. Shi et al. found that removing the weak ties in a test case did not disconnect the network; rather, ‘the network sheds some nodes and shrinks modestly’. The result is that a high-fidelity strong-tie social network, made up of overlapping clusters, spreads information at almost the same efficiency as the network linked together with long-distance weak ties. A combination of the two is the most accurate representation of the real world, in which both overlaps and weak ties connect the network, like the giant component does in physics, and make possible an ‘information cascade’—equivalent to a phase transition.
Networks and Diffusion

Power Laws and Restriction of Power Laws

An important development in understanding spread on networks resulted from the discovery of Barabási and Albert, who found that instead of following a ‘normal distribution’ when plotted graphically, many real-world networks are highly skewed, the majority of nodes are poorly connected, a few have massive connectivity. This demonstrates a ‘power law’, where many small nodes coexist with a few very large ones. Power-law networks have ‘hubs’, nodes that are disproportionately well connected. Hubs exist partly because of preferential attachment, i.e., the probability of a new node joining to an existing node is proportional to the number of links that node already has. A node attracts new links largely on the basis of already having links. Seniority within a network is one of the main reasons a node will become a hub, but other aspects of identity are also factors. These allow for the ‘lock in’ of fluctuations, amplifying differences over time.

Power laws have been found to occur frequently in many real-world situations (for example, distribution of wealth, popularity of websites). However, human interactions are different and more subtle than all other kinds of networks. The anthropologist Schnegg observed that reciprocity and the recollection of beneficial past acts restrict the development of hubs and power laws in social networks. This leads to the conclusion that in social networks, maximum utility is not as important to most members as reciprocal altruism and being fair—as supported by biological data. ‘Blending reciprocity and memory into transactions reproduces networks much better correlated to the social world.’ This is not to say that hubs do not exist in social networks. Rather, they exist, but their ‘hub’ status does not automatically mean they are universally powerful in attracting links, as opposed to known nodes within a social setting, with which there has been positive historical interaction. Hubs play an important role in transmitting information over a network. In order to understand how hubs function in different network situations, it is necessary first to discuss the processes by which information diffuses through a network.

Using the Network: Transmitting Information

Effective diffusion requires the nodes vulnerable to the new idea, technology and so forth, to be found. Network distance—the number of steps between two nodes—is more important in analysing information transmission than physical distance. Distance is not measured in just one way however, there are many types—geographical, social, professional—every aspect of identity can measure distance. People use knowledge of the identities of their local network to assess the best route, the shortest path to spread information across, known as ‘directed search’. When the vulnerable nodes in a network can be linked together through this process of search, they form what is known as a ‘percolating vulnerable cluster’.
The percolating vulnerable cluster allows information to cascade across it. This can be rapid, as with an out-of-nowhere success story, or slow, as with the change of societal norms. The spread of monotheism may be an example of the latter. Information cascades, like phase transition in physics, are demonstrated by the network as a whole displaying emergent behaviour: individuals stop acting like individuals and behave as though part of an organized group. They are self-perpetuating—picking up ‘new adherents largely on the strength of having attracted previous ones. An initial shock can propagate throughout a very large system, even when the shock itself is small’. But all kinds of shocks happen all the time, yet the system generally remains unaffected.

**Vulnerability to Innovation: Thresholds and Neighbours**

Shocks that trigger cascade do not necessarily represent superior stimuli. Their success is rather an indication of the network structure in which they happen to land, whether the local environment is vulnerable or stable with regard to innovation. There are two ways of assessing a node’s vulnerability, either ‘it has a low threshold (thus, a predisposition for change); or because it possesses only a very few neighbours, each of which thereby exerts significant influence’.

People have a ‘critical threshold’ whereby an opinion about something can jump abruptly from one alternative to another. Sometimes, the threshold is very high, when complete unanimity of solicited opinion is required to cause the individual to switch (even then they may not do so). Often the threshold is much lower, with fewer obvious differences between alternatives. At this level, neighbourly influence is vital to an individual’s decision to switch. If an individual observes enough endorsement of a particular choice, they are likely to switch, especially if those people are part of socially powerful relationships, regarded as being of higher status, or known to have made ‘good’ decisions in the past.

The ‘threshold rule’—the position of an individual’s threshold—will be subject to change depending on the nature of the innovation. Some are willing to adopt something about which they have little information; others are more conservative. In the 1960s Rogers, in a discussion of the adoption of technological and organizational innovation, identified five groups in the population: *innovators*, venturesome, intelligent, technologically aware, often with substantial financial resources; *early adopters*, socially respected opinion leaders; the *early majority*, deliberators central to legitimizing the innovation; the *late majority*, sceptical about the new who adopt out of necessity; and *laggards*, the traditionalists. This is more like a continuous scale of awareness to adoption, and the details of these categories may need modification to apply to innovations in ideologies and beliefs. Many factors affect an individual’s position, including age, education, environment, class, gender, religion, and financial and social status. People also have varying degrees of trust in different sources of information.
Layton observed that it is ‘those individuals who are the first to adopt innovations who are of prime importance. They act both as a bridge and a buffer between their fellow villagers and the outside world by bringing detailed knowledge of innovations into that community’.

The innovators must be connected to early adopters if the innovation is to spread. The success or failure of an innovation may be defined by the criteria used to judge it: is success marked by the time taken for an innovation to be accepted, general depth of understanding, or legitimization by a social leader? Additionally, it must also be asked how the new information is converted into knowledge that is trusted and applied, not simply possessed.

Mathematically, nodes are more stable the more links they have, because they are less likely to be influenced by any one link. Watts uses the term ‘critical upper degree’ to describe the ‘number of neighbours a node can have and still be activated by one neighbour’ — a node’s boundary between retaining the status quo and adoption of the innovation. A node will be stable if it has more neighbours than this degree. By this logic, hubs will be the most stable nodes of all.

**Boundaries and Cascade**

Mathematically, cascades will not occur for three reasons. First, no node’s threshold is low enough: the innovation does not persuade. Second, the network is not well connected enough: a disconnected network is vulnerable, but does not percolate fully; it is therefore unable to spread influence. Third, it is too well connected: the majority of nodes are stable because of neighbourly influence and so, even though they percolate fully, cannot be part of a vulnerable cluster. This creates two boundaries within which information cascades can occur: the lower boundary, below which the nodes have too few neighbours, and the upper boundary, above which the nodes become too densely connected.

Full network cascades only happen if the innovation activates the vulnerable cluster of highly connected nodes near the upper boundary. The percolating vulnerable cluster is tightly integrated with the rest of the network here, and so initially stable nodes will be exposed to multiple early adopters, causing them to activate. The prerequisites are difficult to achieve, making the upper boundary cascade very rare, but when an innovation does activate the vulnerable cluster here, the high connectivity means the entire network will follow and global cascade occurs. This is known as ‘crossing the chasm’.

Because nodes at the upper boundary are so well connected, it follows that ‘cascades are almost as likely to be triggered by an individual with an average number of neighbours as someone to whom many people pay attention; … being simply well-connected is less important than being connected to individuals who can be influenced easily’. Conversely, at the lower boundary, because nodes are vulnerable to neighbourly influence, ‘highly connected individuals are disproportionately effective in propagating social contagion’. This fits better with diffusion of innovation theory,
which classes early adopters—opinion leaders with both long-distance links and high social integration—as the most effective promoters of new ideas or technology.

**Problems and Ways Forward**

This leaves a number of issues to be addressed. First of all, why are highly connected individuals not effective at the upper boundary too? There are two types of cascade: lower boundary, where hubs play a central role in diffusion, and upper boundary, where hubs are too inherently stable to be effective transmitters. This may make sense mathematically, and perhaps works in some network examples, but it is socially paradoxical. Early adopters, by definition respected opinion leaders, are likely to be well-connected nodes, possibly even a local hub. In real terms, these individuals are the most effective at spreading information—having lots of neighbours is the fastest way of transferring innovations. It is difficult to see how information can spread on a social network without these nodes being involved, regardless of their mathematical stability.

These problems arise partly because identity has been left out of the mathematics for simplicity’s sake. But social connections run in different directions: the node can be doing the connecting, or be being connected to. Sometimes this will be mutual, but there are divisions between active and passive links that need to be distinguished in the developed model of cascades. The frequency of the interaction, and its fidelity, must be considered in the theorization of diffusion in social networks: there is connective directionality and asymmetry as well as variance in values of different group participations.

Another issue is the role of the missing third link in the chain, the early majority. Mathematically, the network does not explain the legitimization process — it ignores it by making the stable nodes all identical, simply switching under the collective pressure of being connected to many early adopters. Socially, this is not the case. Understanding legitimization is central to understanding how innovations spread from being small pockets of adoption to being cascades of information.

**Networks and Religious Innovation**

Information spreads along both horizontal and vertical axes. Horizontal transmission refers to peer similarity, represented, for example, by copying without understanding, whereas vertical transmission requires a depth of knowledge and experience, for instance through conditioned learning. Religious information is transmitted both ways. One can horizontally copy or superficially appreciate aspects of a new cult, for example, by acknowledging a deity that is represented in a familiar way, but full understanding will be a vertical process, of learning and adapting a particular ritual format, liturgy, or set of physical movements.
 Monotheism as a Religious ‘Innovation’

Although the philosophical argument for one god was well known amongst the intellectual elite, and a ‘monotheistic trend’ has been observed during the Imperial period, monotheism can be called a religious innovation within the milieu of Imperial polytheism. The future application of these theories in this investigation seeks to understand the reasons why monotheism was so successful at this juncture. What circumstances had changed in order for monotheism to take hold? To whom was monotheism attractive, why did they convert, how did it favour them individually, and how are they defined? Does ‘vulnerability’ to a new faith involve having disposable time or income, a particular occupation, is it to do with age, status, gender, or ethnic identity? Did transmission follow set routes, or random connections? Anthropologically, in general it is young men who travel and trade, and they that access and transmit new ideas. However, socially, the elder generation possess the experience to be effective religious leaders. Can this conflict be reconciled?

One way to set about answering these questions is to combine the theory of innovation with that of religious conversion. Social interactions are dynamic and transitory, with a transactional nature: the value must be equal to, or greater than, the cost. Directionality (i.e., give and take) of transactions means that over time asymmetries in that give and take become ‘locked in’, as has been observed above in the emergence of network hubs. Power relationships and inequalities result from social interchange dependent on, for example, an individual’s status, resources, talent, etc. These aspects are both self-determined as well as predetermined.

Conversion and Evolution

Some sociologists of religion have sought to explain religious conversion (or ‘recruitment’) through an analysis of social interactions. Stark has shown that status, background, and environment are important, but that social contacts are crucial to an individual’s receptiveness to a new cult.

The basis for successful conversionist movements is growth through social networks, through a structure of direct and intimate interpersonal contacts. Most new religious movements fail because they quickly become closed, or semiclosed networks. Successful movements discover techniques for remaining open networks, able to reach out and into new adjacent social networks.

His analyses of the spread of early Christianity argued that the combination of Christian ideology/self-representation within historical environments—from the disease epidemics of the second and third centuries, to Christian (as opposed to Roman, not Jewish) treatment of women—reconfigured the ratios of pagan to Christian in social networks in a way that ensured the ‘inevitable’ triumph of Christianity. Instead of taking the quality of religious stimulus as given, conversion should be understood as a social process, conditioned by people’s networks driving the religious change. This approach does not ignore transcendence, or judge the truth
of the ideology; it instead engages with the social aspects of why humans believe. The ideology of a religion will always be part of the explanation of conversion. However, regardless of the persuasiveness of an ideology, or the transcendence of a vision, conversion does not happen in a social vacuum.

It is relevant at this point to consider religious innovation within an evolutionary framework. Simplistically, biological innovations are successful if they favour the individual gene’s chances of survival—in a sense, the genes are motivated by self-interest, and direct the organism in which they are contained to maximize chances of survival, either individually through reproduction, or through kin-selection. The term ‘meme’ has been coined for ideas that propagate via human consciousness, just as genes propagate through organisms over generations. This form of argument is familiar to archaeologists; Shennan examines cultural development from an evolutionary perspective. He cites work by Boyd and Richerson suggesting that ‘culture can usefully be seen as a system of inheritance’ and which is subject, as a consequence, to random fluctuations and errors of the type seen in genetic mutation. However, this refers to technological innovation. Ideological innovation is much more difficult to study, but traces can be found in records of new practices or rituals. The utility of a technological innovation means that this kind of innovation can be classed as ‘evolutionary’; it follows a (generally) strict, unidirectional linear pathway. Some biologists have criticized the network approach to understanding religious transmission, and argue instead that monotheism’s success should be understood in terms of individual self-interestedness, that a religious innovation should possess inherent utility, and its adoption and diffusion involve a process akin to natural selection, propagating beneficial elements and discarding useless or harmful ones. Therefore, critics argue that it is the value of the innovation rather than connectivity of the network that determines success or failure.

Responses

There is not enough space here to deal with these challenges in full; however, evolutionary and network approaches are not mutually exclusive. It is a given that any innovation possesses inherent value within the context in which it was developed. The network structure simply determines how profoundly it will spread. Random fluctuations, the ‘genetic mutations’ of biology, become set over time, initially (although not always) because they are better suited to the environment. This is particularly clear in the physical characteristics of networks, for example in the geographical location of nodes, communication routes, etc., but eventually the network will change if there is a more effective and efficient alternative. Can religion be claimed to follow a similar developmental trajectory? Ideas do not impose themselves, but depend on the stance that an individual takes in regard to them. It is perhaps more helpful to term religious innovation as a dialectic of ideas rather than strictly as an evolution.
However, the utility of religion can be identified in the social environment into which the convert is admitted, as well as in its intrinsic properties and ideology. Beliefs have utility for those who hold them, as they believe in their utility. An individual will only convert if it is in their interest, and this self-interest is likely to drive conversion only if there are social benefits to be gained. In certain periods, and in particular environments, the religious status quo will undergo sudden upheaval as a response to social factors, and the emergence of a religion that has more utility for its believers. Parts of the system will mutate, while others remain the same. The question is then: will these traditional forms, which have not adapted to the environment and needs of the believers, eventually become extinct?

Some parts of the system have more freedom to mutate than others. Mathematically, the looser structure of networks at the ‘peripheries’ (near the lower boundary) is more conducive to short-lived change than the upper boundary ‘core’. Is the social situation similar? As Stark writes, ‘typically, the fate of new religious movements is largely beyond their control, depending greatly on features of the environment in which they appear.’ Peripheral religious innovation makes sense; orthodoxy is generally imposed from the static, traditional centre, controlling standards through official shared rituals. For example, in the Roman Empire during the third and fourth centuries, Christian ‘orthodoxy’ ultimately spread despite competition from various ‘heresies’. However, at this point, it was not really the orthodoxy; it was a version of Christianity that happened to have reinforcement from Imperial legislation, and thus provided the ‘best fit’ for most people’s social environment—the expenditure of least effort and energy. It became central as a result of the action on the network. Elsewhere, other ‘orthodoxies’ prevailed.

Network Approaches to the Past and Future Directions for Theos Hypsistos

Ancient networks concerning trade, technology, and communication have already been studied, built on centralization/diversification and complexity models, or cultural transmission theories. Recently, archaeologists have used networks in a more theoretical way. Isakken used GIS and network analysis software to demonstrate the correlation between the physical and network locations of key political sites in Roman Baetica. Bentley and Maschner explored the potential of mathematical complexity theory in archaeology, and Knappett has collaborated with physicists to simulate Minoan networks across the Mediterranean. Broodbank conducted a Proximal Point Analysis (PPA) to simulate and predict Early Bronze Age Cyclades settlement patterns, drawing contact lines between a site and its three closest neighbours. A useful result is the transparent demonstration of site centrality or remoteness, and although these values can be intuited correctly, the method highlights issues or anomalies missed by common sense.

Malkin uses networks and network language to explore Archaic Greek colonization: ‘Awareness of “sameness” occurs not when people are close to each other . . . but when they are far apart. It is distance that creates the virtual centre. The more the connecting
cables are stretched, the stronger they become." This idea that distance helps to create identity may be relevant to the study of widely distributed religious communities, although a ‘virtual centre’ is not necessarily also created. Mitchell’s analysis of the cult of Hypsistos argued for its distinction from, but close connection to, Jewish Diaspora communities: many of the believers were ‘Judaizers.’ The networks of ‘Hypsistarians’ and Jews are geographically fairly close, but what about ideologically and socially, in their own self-perception, and as perceived by the societies of which they were part? Questions that will arise in my application of network theory to historical data include: is the Hypsistos cult an example of a heterarchical network, a religious network without a centre, fundamentally different from an institutionalized, centralized, sanctuary-focused hierarchical church? In other words, is pagan monotheism characterized by its network? Or is this kind of network a characterization of early-stage cults, before they ossify into the full-network norm, and become the ‘traditional’?

These approaches should lead to developments in understanding of the cognitive or physical space for new cults in the ancient world. Comparison of networks will allow the observation of crossovers or interchanges and the domination of certain cult distributions. For example, perhaps once a cult is settled there is no ‘room’ for another similar one, and the evidence shows examples of unsuccessful, partial cascades. How would Christianity have used those half-activated vulnerable clusters? Mitchell concludes that ‘without them [the Hypsistos worshippers], the transformation of ancient patterns of belief from pagan polytheism to the predominantly monotheistic systems of Judaism, Christianity, and Islam would not only have been far less tidy and unidirectional than it was, it might not have occurred at all’.

**Problems and Potential**

Assessing network structure rather than the ‘stimuli’ of historical events leads to a different way of understanding the past. Instead of viewing historical success as a measure of inherent merit, using networks means the observed outcomes of historical situations need not be ‘superior’. They are survivors. Biological survival depends on ‘best fit’. However, the theory of cascades suggests that inputs and outcomes are not necessarily proportional, yet the biologists’ view is the opposite — the input generally requires enough utility for it to be selected for transmission. Are social and biological selection processes representative of different phenomena with different rules, or can evolution be fully incorporated into an understanding of social emergence? This paper has attempted to go some way to reconciling these views, but this must be developed further. For example, does the fundamental difference in scale, the complexity and the active agency involved, render ‘natural selection’ too blunt a tool to apply to historical situations?

There are obvious problems with theoretical approaches to the ancient world, particularly the uneven patterning of evidence and the application of modern interpretive frameworks. Networks, through their simulative as well as data-responsive
functions, may help to fill some gaps. Ancient history and archaeology can provide
time depth in which to test network theory, and to investigate similarities and
differences between information transmission in pre-modern and modern society.

However, modelling cascade on networks is not a finished answer to these problems.
At present, the threshold rule is highly idealized, and further development of this
colornt is necessary. Certain assumptions have also been made in innovation theory
that need modification for the ancient world—for example the financial independence
of innovators in antiquity, or the likelihood of non-geographically defined friendships.
Instead, inter-community contact, patronage systems, or technological innovation as
prestige-indicator might be more useful terms to employ. Equally, although occasional
individual early adopters have been identified (for example, the apostle Paul[44]) it is
nearly impossible to distinguish such people from the information generally available.
Identifying early adopting groups may be easier.

This paper has intended to demonstrate that network theory holds great potential
for approaching ancient data. There is more to be thought through and tested, and
many aspects of the theory need further development, but with additional refinement,
the theory of networks and the diffusion of information could become as fundamental
a tool for understanding social and religious change and communication in the past as
it is proved for understanding these aspects of society in the present.

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AHRC project at the University of Exeter: ‘Pagan Monotheism in Its Intellectual Context’.

Notes

[3] Ibid., 53.
[8] Ibid., 2.
[10] The line creates a curve indicative of the rule of the average — i.e., very few nodes, if any, have
    no connections, and very few nodes, if any, have an excessive number of connections.
[14] However, in the ancient world, physical distance constricts network closeness in a different way
to modern networks.
This distinction may be particularly pertinent in modelling religious change.

Watts, Six Degrees, 224.

Rogers, Diffusion of Innovations, 169–71.

Layton, ‘Pellaport’.

Ibid., 50–51.

Watts, Six Degrees, 234.

Ibid., 237–38.

Ibid., 242.

Ibid., 243. This could aid understanding of how cults propagate, through deliberate ‘search’ for individuals with low thresholds or few friends to keep them ‘stable’.

Ibid., 240.

See Knappett, Thinking Through Material Culture.

Philip Jenkins, Penn State University, in response to paper by Bas van Os, University of Groningen, at the SBL/AAR AGM in Washington, DC, November 2006.


Ibid., 20.

Dawkins, Selfish Gene, 189–201.


Ibid., 334.

Not to preclude simultaneity—technological innovation bringing with it an ideology or associated religious belief, for those who use it, or who carry it.

In conversation with N. Collar, BirdLife International/Department of Zoology, University of Cambridge.

Stark, Rise of Christianity, 191.

Isaksen, Network Analysis of Transport Vectors in Roman Baetica.

Bentley and Maschner, Complex Systems and Archaeology.

Evans et al., Thinking Through Material Culture.

Broodbank, An Island Archaeology of the Early Cyclades.

Malkin, ‘Networks and the Emergence of Greek Identity’, 59.

Mitchell, ‘The Cult of Theos Hypsistos’.

Ibid., 128.

Barabási used Paul as an example of an ancient hub in his introduction to Linked.

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