

Scale, Information-Processing, and Complementarities in Old-World Axial Age Societies

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Abstract: Recent cross-disciplinary work on quantifying historical dynamics has made major contributions to scholarship. However, efforts to specify relationships between scale and information-processing always run a risk of shoehorning messy realities into overly rigid categories. In the case of the first-millennium BCE “Axial Age” in the Old World, networks of collective computing were structured more by cultural systems than by polities, and to understand the relationships between political scale and collective computational abilities, scholars need categories flexible enough to clarify the complementarities between political and cultural systems.

Key words: scale; information-processing; Axial Age; ancient Greece

1 Introduction

Academic administrators like to joke that the difference between social scientists and historians is that the former are ignorant while the latter are stupid. (Seen from a dean’s vantage point, archaeologists are apparently indistinguishable from historians.) Social scientists leap to absurd conclusions because they do not know very much; historians do not reach any conclusions at all because they are not bright enough to spot the patterns. And as for people like the Santa Fe Institute’s Working Group on the evolution of collective computational abilities—well, like all fudgers and compromisers, we risk ending up with the worst of all worlds, with the stupidity of some of our number compounding the ignorance of others.

Maybe so—yet it is hard to see how we will transcend either ignorance or stupidity without running this worst-of-all-worlds risk. If there really are laws governing the relationship between social scale and information processing, we will need sophisticated statistical analyses to uncover them, but no such analyses are possible until we find ways to convert the teeming,

seemingly incommensurate variety of lived experience into abstract, cross-culturally and diachronically comparable units. So, however great our ignorance and/or stupidity, social scientists and historians/archaeologists must work together.

The Seshat project^[1] is making major contributions in this regard, and Shin et al.’s analysis of its data^[2] has advanced an important hypothesis, but I suggest here that the most valuable result to date to come out of this scholarship is perhaps its demonstration that scientist/historian collaboration needs to be deepened further still if we are to find completely convincing answers. Looking at one of the historical cases that Seshat has studied most thoroughly^[3], the “Axial Age” societies of the first-millennium-BCE Old World, I suggest that some issues remain to be resolved with the units of analysis. Seshat classifies its data primarily by “polities”, a broad name for political organizations of every scale, from foraging bands to agrarian empires. While this is often the most practical way to organize the material, there do seem to be times when the polity is not the best unit for measuring organizational scale, and arguably more times when it is an inappropriate unit for examining collective computation. I suggest that the Working Group’s project actually calls for a more flexible classification system, better able to distinguish between a variety of kinds of associations.

After beginning by sketching some of the main

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features of Axial Age societies, I zoom in on one specific example, Greece in the archaic and classical periods (roughly 700–300 BCE). Here the mismatch between the scale of political units and that of the cultural units that revolutionized collective computing capacity is particularly striking. On the face of it, Greece might seem to falsify Shin et al.’s claims about scale thresholds, but that would probably be a simplistic way to think about the analytical issues. What the Greek case actually shows, I suggest, is that we need more analytical flexibility than the catch-all category of “polity” can provide. In the final part of the paper, I propose that the most interesting question about scale and collective computation in the Old-World Axial Age is why some of its large, coercion-intensive empires proved so much better than others at co-opting the small, capital-intensive cities where most of the intellectual innovation took place. Size mattered—but so did technique.

2 Old-World Axial Age

The first millennium BCE was a time of spectacular growth in Old World polities. Around 1000 BCE, the biggest cities on earth—probably Qi in China, Susa in southwestern Iran, and Tanis and Pi-Ramesse in Egypt—each had not much more than 30 000 residents; by 1 BCE, Rome had a million. In 1000 BCE, Egypt ruled some 2.5 million subjects spread across 400 000 km²; in 1 BCE, the Roman and Han Chinese Empires each controlled some 4.5 million km² and perhaps 60 million people^[4].

Turchin et al.’s^[5] five categories of collective computation—government, money, infrastructure, information system, and texts—are harder to quantify, but almost certainly saw comparable increases. There was no coinage at all when the millennium began, but by its end, the Roman and Han Empires each had several billion pieces of stamped metal circulating, serving as units of convertibility and measures and stores of wealth. Nothing in the tenth century BCE bears comparison with first century Rome’s roads and harbors or China’s postal service. In the tenth century BCE, a few thousand people could read a limited range of texts; in the first, several million people could enjoy a large body of literature. Libraries in Rome and Alexandria held hundreds of thousands of books and ordinary soldiers were writing poetry in Britain and Egypt. Babylonian astronomers were observing the stars and calculating their orbits well before 1000 BCE, but by 1 BCE, Greek scholars knew

that the earth was round, how big it was, and that it orbited the sun, rather than the other way around.

Arguably, the biggest change of all was in frameworks for thinking about the world. Some of the philosophies/religions that became so important between 800 and 200 BCE—Confucianism and Daoism, Buddhism and Jainism, Platonism and Stoicism, Judaism, and possibly Zoroastrianism—constituted nothing less than moral revolutions, offering radically new visions of how humans related to each other, their rulers, and their gods. This was the moment, the philosopher Karl Jaspers portentously announced in 1949^[6], that “Man, as we know him today, came into being”. Jaspers called these centuries the “Axial Age”, because he saw them as the axis around which the world’s moral history turned. No one can prove that Axial thought was causally connected to the enormous scaling-up of first-millennium-BCE Old World polities, or which way the causal arrow points, but no society other than those that went through an Axial intellectual revolution (or was taken over by colonists whose ancestors had been through such a revolution) has ever grown so large.

Jaspers’ own analysis tended toward the metaphysical^[7], but in the 2010s, Seshat and other research teams quantified the data more rigorously. There have been fierce debates over whether the numbers show that belief in moralizing “big gods” who rewarded prosocial behavior preceded and made possible the growth of bigger, richer, and more complex states^[8], whether the reverse was true^[9], or whether we should just conclude that the new thinking “coevolved gradually with larger and more complex societies”^[10]. My own comparisons of Eastern and Western Eurasia make me suspect that state formation did come first^[11, 12], but also seem to suggest that there is a problem with our units of comparison. The places that saw the greatest developments in intellectual capacity were not the same places that experienced the greatest scalar growth. In China, Confucius came from the little state of Lu, not from all-conquering Qin. In India, the Buddha hailed from mountainous Sakya, not mighty Magadha. The Hebrew Prophets spoke to God in the backwaters of Judea, not in Nineveh. And Socrates came from Athens, not from Susa or Persepolis. The big ideas of the first millennium BCE came from the geographical margins, not the centers of power, which perhaps means that the

relationship between intellectual innovation and demographic and institutional growth was more complicated than the categories currently being used allow for.

3 A Greek Miracle?

Greece in its archaic (~700–500 BCE) and classical (~500–300 BCE) eras is the most extreme case, and also the most illuminating. By the standards of great first-millennium empires like Persia or the Han, Greek polities were tiny. Most Greeks lived in city-states, of which there were several hundred at any moment, and even the biggest (by most ways of measuring), Athens, possessed only 2400 km² of real estate. You can walk from the Parthenon to any point in Athens' territory in a single day. However, Athens and many other city-states were very densely settled. The urban center of Athens probably never had more than 40 000 residents, but there were over 300 000 more people in its small territory in the 430s BCE, for an overall density above 100 per km². This would not be surpassed in Greece until the twentieth century CE^[13, 14].

These small and crowded city-states made spectacular advances in collective computing. Famously, Greeks invented the first full alphabet around 800 BCE, taking a Phoenician consonantal script and repurposing some of its symbols to represent vowels. We have no good way to quantify literacy rates, but chance survival of graffiti carved on rocks, business contracts engraved on lead, and dedications scratched on pots suggested to the ancient historian Harris^[15] that at least 10 percent of male citizens had basic reading and writing skills—a truly exceptional rate for the first millennium BCE. Greeks also either invented metal coinage, around 600 BCE, or almost immediately adopted it from inventors in the neighboring kingdom of Lydia (in what is now western Turkey). Greeks created the most sophisticated knowledge markets the world would know until the seventeenth century CE, using writing not just to list knowledge and practices (the way it was overwhelmingly deployed in other East Mediterranean societies) but also to explain ideas from first principles, making them accessible to readers and imitators who had entirely different professional and cultural backgrounds than the authors. It was these knowledge markets that made it possible for thinkers like Pythagoras, Aristotle, Archimedes, and Ptolemy to theorize topics as diverse

as physics, biology, astronomy, politics, architecture, music, and ethics in entirely new ways. By 500 BCE, Greek doctors were considered the best in the Mediterranean, and in the third and second centuries BCE, Greek engineers and scientists established principles that would continue to guide European thought until the sixteenth century CE. In the first century BCE, Greeks in Egypt made steam-powered machines and working models of the (known) solar system. Growing numbers of Greek city-states also became male democracies after about 500 BCE, in which all men born into citizen families (which comprised at least two-thirds of the resident population), without regard for wealth, education, or further distinctions of birth, could vote, speak publicly, and hold most political offices. Greek democracies' embrace of slavery and steep gender hierarchies made them much narrower in some ways than modern democracies, but their aggressive rejection of privileges based on wealth or training made them wider in others. Thousands of male citizens pooled their knowledge in regular mass meetings, crafting laws to reduce transaction costs and increase transparency. Greek population grew tenfold between 800 and 300 BCE, but rather than experiencing Malthusian catastrophe, Greece actually saw per-capita consumption increase across this period by roughly 50 percent. So far as we know, real wages in the fourth-century-BCE Athens were higher than in any other premodern society^[14, 16–21].

Confronted by this extraordinary record, Europeans since the eighteenth century have regularly spoken of a “Greek miracle”. Wilhelm von Humboldt, writing in 1803, thought that “the Greeks step out of the circle of history ... from the Greeks we take something more than earthly—something godlike”^[22]. In the nineteenth and early-twentieth centuries, Europeans and Americans sometimes treated ancient Greece as a foundation myth for white supremacy. This subsequently generated a strong backlash, but even after a hundred years of debunking, it remains clear that the Greek achievement in collective computing has few, if any, parallels^[14].

An argument could certainly be made that the Greek case, combining small political scale with extraordinary advances in collective computing, falsifies Shin et al.'s^[2] interpretation of the Seshat data, and perhaps even undermines the entire Seshat project^[1]. However, that would be a serious overstatement. The problem lies

not with the idea of converting the raw material of human history into serial data that can be compared across time and space or the search for regularities, but in applying the same classificatory unit—the “polity”— to all spheres of activity.

As Aristotle observed (*Politics* 1252a1-6), humans form different kinds of organizations to achieve different ends. Families, firms, polities, churches, and armies work in very different ways, each of them better than the alternatives for organizing some categories of collective action and worse for organizing others. The historical sociologist Michael Mann has proposed a useful typology, dividing the sources of social power into the four categories of ideological, economic, military, and political^[23]. Mann suggested that in every society, different people have comparative advantages in different sources, and they then compete and/or cooperate to extend their strengths in one form of power into control over other forms of power. The struggles that result—between church and state, rich and poor, military and civilian, and town and country—fill the historical record. In the last five thousand years, political actors have regularly succeeded in asserting monopolies over the legitimate use of force within defined territories, the heart of Max Weber’s celebrated definition of the state^[24], and states have normally asserted priority over all other organizations within that territory. However, Mann pointed out, these claims are (to varying degrees) more aspirational than factual: rather than belonging to a single “polity” coterminous with a state, each of us belongs to multiple, overlapping, and often competing power networks.

This can be a useful way to think about scale and information-processing. Politics are one of the relevant categories whose scale we might measure, but are not always—perhaps even not often—the best category for capturing intellectual innovation. The Athenian polity had about 350 000 members in the 430s BCE and the city-states led by Athens in the alliance that historians rather misleadingly call the “Athenian Empire” perhaps another 2 million. But neither of these organizations is the appropriate unit for thinking about the Greek revolution in collective computing, which was happening across a much larger Greek cultural network, stretching geographically from Cyprus to Spain and containing 5–7 million people.

Like all cultural networks (and even the word “culture”

itself), this one is hard to define^[25, 26]. It had a degree of physical unity, lying entirely within what geographers call the Mediterranean biome, which gets enough rain to grow barley, wheat, olives, and grapes. Plato famously described the Greeks as clustering around the Mediterranean and Black Seas “like ants or frogs around a pond” (*Phaedo* 109b). Maritime communication within the network is unquantifiable but was clearly intense, and most cities hosted communities of immigrants who had been born elsewhere (known as *metoikoi* or *metics*, “those who live together”), some of them identifying as Greek, others as Phoenician or other ethnicities. Language and material culture both served to distinguish the Greek culture zone from other zones in the Mediterranean, although, as anthropologists trying to define culture zones always find, there was a lot of fuzziness. Internally, there were differing dialects and local art styles, and Greeks distinguished between Dorian, Ionian, Aeolian, and other ethnic sub-groups defined by descent from mythical ancestors^[27]. Externally, multilingualism was common and Greek formed a widely used argot. Greek material culture was also widely imitated and adopted around the Mediterranean after about 600 BCE. Arguments sometimes raged over how “Greek” peoples such as the Carians, Macedonians, and Romans were. Even so, when Aristotle decided in the 330s BCE to have his students write up accounts of the political systems of the Greek city-states, only one of their 158 case studies—the Phoenician colony of Carthage—was not primarily Greek by language, ethnicity, and material culture. In the end, we can probably do no better than to follow the definition of *ta Hellenika*—“the Greek things”—set out by Herodotus (8.144) to describe what an alliance of Greek city-states claimed to be defending against Persia in 480/479 BCE: “the community of blood and language, temples and ritual; our common way of life”.

Athens was certainly the most important place within this network, but hundreds of other city-states acted as nodes, linked by maritime communication and open markets for goods and ideas. Agents within this system were highly mobile, regularly relocating to exploit career opportunities. The city of Athens was the strongest attractor, thanks to its wealth, the patronage provided by democratic festivals and institutions, and the determination of some of its leading men (especially Pericles) to make it “the school of Hellas” (Thucydides

2.41). Only 1 percent of Greeks lived at Athens, and 5 percent in the whole of Athens' territory; but if we look at the *Oxford Classical Dictionary*^[28], a standard reference work collating basic information, we find that fully 50 percent of the fifth-century cultural figures about whom details survive ($n = 147$) were born at Athens, and fully 70 percent spent significant portions of their careers there^[29]. This was a very fluid network.

We can complement Mann's typology with a second sociological framework. In a classic book on second-millennium-CE Europe, Tilly^[30] drew a distinction between what he called coercion-intensive empires and capital-intensive cities. The former held a comparative advantage in violence, the latter in information. Empires effectively outsourced brainwork to capital-intensive cities, in a complementary relationship. Neither cities nor empires could succeed without the other. Empires tried to run protection rackets, defending cities against predators (especially themselves) in return for taxes and other services; and cities tried to sell administrative services to empires for the highest prices possible. Yet for all their interdependence, the cities and empires that Tilly studied formed two complementary networks, partly overlapping, partly competing, and partly cooperating.

None of this would really matter for the relationships between political scale and information-processing if we could simply assume that despite their differences, political and intellectual networks had a 1:1 correspondence, so that growth in the scale of the former correlated tightly to growth in the sophistication of the latter. Shin et al.'s principal component analysis suggests that there were indeed connections between the two kinds of networks, which could sometimes be tight (although the error bars do increase significantly between -2.5 and -20.5 on PC1), but the historical record also shows that more was going on than the scores initially reveal. Intellectual systems were only loosely constrained by political boundaries. If we want to make lawlike generalizations about scale and collective computing, we must understand not only the size of polities but also the techniques used to integrate them with intellectual networks.

4 Complementarity

Political leaders do not always find it easy to work with

the kind of people who can revolutionize collective computing. The one time I saw US President Barack Obama deliver a speech, opening a cybersecurity summit at my university, he devoted a substantial part of it to the difficulties his administration was having in attracting and retaining top coders^[31]. Disruptive intellectuals rarely fit comfortably into the formal, steep hierarchies of governments. Such people often feel a need to stand apart from social conventions, and this can regularly spill over into criticism of those conventions and even downright countercultural behavior. Socrates made his name by annoying the leading politicians in Athens; Diogenes the Cynic went out of his way to insult Alexander the Great. Alexander forgave Diogenes, but the Athenian democracy executed Socrates. Confucius, the Buddha, and the prophets Samuel and Isaiah—the great thinkers of the Axial Age—were, on the whole, bad news for rulers.

That probably partly explains why the biggest ideas of the first millennium BCE bubbled up not in imperial capitals but in places like Israel and Greece—relatively marginal, smaller-scale, and more loosely structured groups of cities and statelets at the edges of the great empires. These places also proved difficult (although not ultimately impossible) to incorporate into imperial structures, fighting back fiercely against attempts to conquer them and regularly rebelling if conquest succeeded.

Some empires, however, were much better at incorporating and coopting networks of intellectual innovation than others. The Romans and Han were particularly good at this; the Assyrians and Qin, particularly bad. When Assyria conquered the Kingdom of Israel around 720 BCE, for instance, it massacred or deported large parts of the population, who thereafter disappeared from the historical record as an identifiable group. Had Assyria's King Sennacherib succeeded in storming Jerusalem in 701 BCE, the Kingdom of Judah would almost certainly have met same fate, leading to the loss of the Hebrew Bible and the entire tradition of Judaism.

Assyria's handling of Babylon was arguably even clumsier. In the eighth century BCE, Babylon was the biggest of several dozen more-or-less independent city-states in southern Mesopotamia. Its institutions were relatively egalitarian by the standards of the times, and it was the major center in every field of Middle Eastern

scholarship, from astronomy to poetry. Babylonian learning and institutions had massively shaped Assyrian elite culture, and when Assyria's King Tiglath-Pileser III defeated the city in 729 BCE, he bent over backwards to accommodate himself to its traditions, going so far as to lead the New Year's Day parade to the temple of Marduk in person. However, Babylonians proved as unwilling to cooperate as Israelites, and staged great revolts in 721, 710, 703, and 694 BCE. Sennacherib, the same king who had besieged Jerusalem, thoroughly sacked Babylon in 689 BCE, only for his successor Esarhaddon to realize that the empire needed a flourishing Babylon, and to re-found the city nine years later. Assyria never managed to create much of a shared value system among the local elites it defeated, and when imperial overreach began pulling the empire apart after 630 BCE, its provinces and client kings, including King Josiah of Judah, saw little to gain from preserving it. Babylonians played the leading part in destroying the Assyrian capital of Nineveh in 612 BCE.

At the other end of the Old World, the Qin First Emperor, who unified much of China around 221 BCE, was just as bad as Sennacherib at handling intellectuals. According to one story, he buried alive hundreds of scholars who criticized his brutality. Within three years of his death in 209 BCE, his empire had collapsed into civil war, but the Han dynasty, which had won these wars by 202 BCE, learned from Qin's mistakes. To function at all, Chinese polities needed to hire hundreds of educated men from the lower end of the elite to serve as bureaucrats, and Confucius' teachings had won wide currency in these circles during the fourth and third centuries BCE. In some ways, this was good for rulers, since Confucianism emphasized respect for authority; in others, bad, because Confucius' writings also stressed the bureaucrat's moral obligation to oppose rulers who lacked virtue. Rulers therefore embarked on a long-term campaign to persuade Confucians to privilege the former strand of thought over the latter. The Qin had tried (and failed) to do this by murdering intellectuals who disagreed with them, so the Han instead coopted such men. In a particularly clever move, the Han court agreed that the chief criterion for promotion within the administrative hierarchy would be performance on examinations on the Confucian classics rather than aristocratic connections, and then made sure that the best grades went to scholars who interpreted Confucius'

thought in state-approved ways. They could rely on academics' competitiveness to do the rest. By the first century BCE, the Han had tamed Confucianism, making it a force for conservatism; and in the fifth and sixth centuries CE, successor kingdoms in China applied the same strategy to the potentially even more disruptive thought of Buddhism, an intellectual system that had originally developed on the fringes of Indian empires.

Roman rulers arguably did even better at taming subversive intellectuals. Their city had developed at the edge of the area within Italy settled from the eighth century BCE onward by Greek colonists. Greek models profoundly shaped Rome's Republican political system and government institutions as well as its script, literary genres, and artistic styles. In the third century BCE, however, the relationship between the Roman polity's scale and Greek information-processing systems got more complicated when Rome extended political control over the Greek cities in southern Italy and Sicily; and in the second century BCE, when Romans invaded mainland Greece itself, some military leaders began embracing Greek culture as a lever to fracture Rome's own constrictive norms. Traditionalists such as Cato the Elder tried to protect the institutions of collective senatorial rule by expelling Greek teachers and administrators; radicals such as several members of the Scipio family argued that the only way for Rome to keep winning wars and prospering was by borrowing Greek ideas about godlike kingship. In an astute compromise after 30 BCE, the warlord Augustus—having killed or suborned all his rivals—made himself Rome's first emperor while simultaneously proclaiming that he had restored the Republic. He rebuilt the city of Rome as a grander version of Greek capitals, but also posed as the defender of *mos maiorum*, “the way of the ancestors”, against Greek decadence. Paralleling what the Han had done with Confucianism, the Roman elite then took the most influential Greek philosophical system—Stoicism—and foregrounded elements that allowed intellectuals who bent to the realities of a world with all-powerful monarchs to go on considering themselves virtuous. Stoics ran the Roman Empire just as much as Confucians ran the Han; and the Romans, again like Chinese governments but with even greater success, reran the cooptation script on Christianity in the fourth century CE. (The literatures on Assyria, the Han, and Rome are enormous, but the relevant chapters in

Ref. [32] are good starting points. There are more detailed essays on Assyria in Ref. [33], and Rome-China comparisons in Refs. [34, 35]. I develop my own views in more detail in Ref. [11]. So far as I know, no one has made a systematic comparative study of why some ancient empires were so much better than others at coopting their intellectual critics.)

5 Conclusion

At least in the case of first-millennium-BCE Eurasia, political networks of coercion-intensive empires and intellectual networks of capital-intensive cities have usually been complementary but not coterminous. Each kind of network could grow geographically wider and institutionally deeper only in symbiosis with the other. There were occasions when groups of cities did muster enough military power to hold empires at bay, as when Damascus organized coalitions against Assyria in the ninth century BCE, or when Athens and Sparta did the same against Persia in the fifth. In both these cases, after thwarting attempts to subjugate them, the cities found ways to police for themselves the commercial systems that allowed them to flourish; but ultimately, all networks of cities came to depend on empires for protection against predation. Empires, however, depended just as much on cities as incubators for ideas and institutions. Not all political or intellectual systems proved equally good at this balancing act—which is why technique mattered as much as size in the story of cultural complexity.

I have suggested that the quest for relationships between scale and information-processing is complicated by the fact that the former is often best analyzed in terms of polities and the latter in terms of culture zones that might only be partly captured by any specific polity. If correct, this presents problems for social scientists designing indices and typologies, because culture zones are notoriously difficult to define formally and to operationalize. The ancient Greek world is one of the best-documented premodern culture zones, yet even in this case, there are many difficulties. In designing their very useful *An Inventory of Archaic and Classical Poleis*^[13], for instance, the classicists Mogens Hansen and Thomas Nielsen included as “Greek” several million people living in areas heavily impacted by Greek colonization, even though the archaeologists actually working in these regions generally disagree^[36].

Unsurprisingly, the designers of cross-cultural databases have tended to shy away culture zones as organizational principles. My own limited venture into these waters^[37] was no exception, and left me suspecting that, for all the importance of databases such as Seshat, any one-size-fits-all classification with the ambition of providing information to answer every question about every part of the world in every period of history inevitably runs into difficulties of the kind discussed in this paper. While large-*n* surveys have enormous contributions to make to comparative history, it seems to me that we will always need to combine their results with more detailed case-studies of the kind that some social scientists call “analytic narratives”^[38].

Abstracting from the details of Assyrian, Chinese, and Roman history to grand theory necessarily involves sacrificing detail, but I suspect that Seshat and the analyses built on it have perhaps sacrificed too much detail too quickly. Turchin is surely right to say that “The history of science is emphatic: a discipline usually matures only after it has developed mathematical theory”^[39], but what that suggests to me is that comparative history is not yet mature. Simplifying our units for analyzing culture to the single category of “polity” might be a shortcut too far. Einstein is said to have said that “In science, everything should be made as simple as possible, but no simpler”^[40, 41]. In this case, getting the right amount of simplicity requires tempering the social scientist’s ignorance with more of the historian’s stupidity—and that, I think, is where the Working Group on the Evolution of Collective Computational Abilities comes in.

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