Development of writing may have uncorked bottleneck in 'collective computation'

February 11 2022

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Analysis of a colossal anthropological dataset that systematically collects characteristics of societies around the world throughout all of human history and prehistory shows that an important bottleneck preventing

growth in 'collective computation'—the ability of social groups to solve problems—may be the development of writing systems.

An essay exploring this hypothesis and introducing a special issue of the *Journal of Social Computing* devoted to the question of historical laws governing collective computation was published in that journal on February 10.

For a long time archaeologists have recognized that writing systems often appear at about the same time as the large settlements we call cities, and the political structures for making decisions and managing data that we call states. Nevertheless, the development of writing in societies around the world is often presented by archaeologists and historians as "something that just happens" without quantitative exploration of why it happens at certain times and places, but not in others.

In 2011, however, the Seshat project was founded to systematically collect a large corpus of data employing over 1500 variables describing societies around the world from the Neolithic up to the Industrial Revolution, and from the scale of villages up to empires. The data are collected at 100-year intervals (or as close as possible to such temporal precision). This dataset has provoked substantial interest in the community of anthropology and history scholars for its promise of being able to quantitatively test hypotheses about 'rules' or 'laws' that might govern the development of human society in a similar way to how the laws of natural science govern physical, chemical and biological systems.

The project has provoked controversy over the accuracy and objectivity of the tagging of these social variables, the current limited breadth of societies being tracked—and especially over the 'scientization' of history. But the researchers involved in the development of the dataset and those who want to use it have welcomed such criticism as helpful in

exploring ways the dataset can be improved.

The authors of the essay used the Seshat dataset to explore rates of expansion of capacity for collective computation—the ability of social agents in nature, including humans, to work together to develop accurate models of their external world useful for solving problems. They suggest the quantitative exploration of questions such as what affects the rate of human social development could open a new field of enquiry called 'social kinetics', by analogy with the field of study in chemistry considering the rates at which chemical reactions take place.

Their analysis of the Seshat dataset suggests that there is a 'bottleneck' in the development of human collective computation. Data suggest that societies must reach a certain size before writing can be developed. Smaller societies do not need writing, and also may not be able to afford the infrastructure it requires. This is what they describe as the 'scale threshold' that must be crossed before societies can or need to develop writing systems. Until this point they use human memory for their primary information storage, supported by external encodings into norms of behavior, craft and artifacts, kinship, mythology, art, and ritual. Once they pass what the researchers describe as the 'information threshold'—in which development of writing systems is the key innovation—societies can achieve almost unlimited growth in size.

As a shorthand, the researchers refer to these findings as the 'Thresholds Model' of development of human collective computation: a framework that suggests social evolution is generally characterized by increases in scale whose rate is almost continually limited by existing computational abilities.

They stress that this model remains tentative and exploratory at this point, especially as it relies on the Seshat dataset, which is still at an early stage of its development and comprehensiveness. Consideration of

additional societies and regions will allow the model to be more generally examined.

"The ramifications are tantalizing," said archaeologist Tim Kohler, the lead author of the paper. "We are a highly social species, but we rarely stop to think about whether our modes of communication may affect the directions our societies take—or can take. Although we're beginning to realize this now in the context of social media, we're trying to extend this logic back several thousand years."

Moving forward, the researchers want to further examine the relationship between scale and collective computation by extending the analysis to more societies, including a search for counter-examples. They also want to explore whether mismatches between scale and how societies use and store information contributes to differences in the success of various societies, and how all this may be conditioned by particularly favorable environments or climates.