

Poster Award. Move to change student poster award to cash award of \$100. Seconded. Discussion – is \$100 enough? Only 5 entries this year, would a cash prize increase interest? Stacey - recognition is the main thing. Motion passed.

Motion to name the student poster award as the R.E. Taylor award at SAA, and the SAS Award at other venues. Seconded, passed.

Bulletin name change. Christian might ask members about this through the *Bulletin*. We might need to keep the same main title to retain institutional subscribers; a subtitle could be added. Christian will continue to consider subtitle name Possibilities include ‘Archaeological Scientist’ and ‘Scientific Archaeology.’

Lobbying. Charles Kolb and Greg Hodgins will look into lobbying possibilities. Our by-laws say we should do that. Need to identify SAS goals in lobbying efforts, generally to increase research funds for archaeological sciences. Will seek to identify most useful Congressional Committees for review.

Michael Glascock. Organizing ACS Symposium on archaeological chemistry for the next annual meeting in Atlanta, March 2006.

Budget. Reviewed and approved.

Next General Meeting. Alternatives were to hold the next General Meeting of the SAS in the context of the SAAs, or the next International Symposium on Archaeometry. Motion put forward to hold the next general meeting at the Archaeometry Symposium in Quebec City. This motion was passed.

Adjourned: 6:25pm.



The 2005 Annual Meeting of the Society for American Archaeology took place at the Salt Palace Convention Center in Salt Lake City, Utah (USA), March 23-29. The SAS Business Meeting was held across the street in the Marriott, the convention hotel.

Making a Case for Agent-Based Modeling

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Archaeologists' knowledge of the past must rely on inference, often from scant material remains. Those of us who are not ethnoarchaeologists are denied the opportunity to directly observe our subjects: we can never watch Plio-Pleistocene hominins interact around a bovid carcass, or Hohokam farmers deal with the complexities of an irrigation system during a dry year. However, computer technology offers a way to view the dynamics of past cultural formation processes in digital conceptual models. Our student-run research group at the University of Arizona has found one relatively new class of models, called Agent-Based Models (ABMs), to be especially useful in this endeavor. Here we discuss the use of ABMs as “cultural laboratories” capable of executing controlled, repeatable experiments and systematically exploring multiple parameters of hypothetical cultural processes. We also provide brief synopses of ongoing projects to introduce research that is currently making use of this promising new methodology.

Agent-Based Models as Cultural Laboratories

A computer model does not simulate reality, but instead represents and encodes our concepts of it. Thus, it is a tool used to explore our ideas about the past, rather than the past itself. Once encoded, a computer model can do what our limited imaginations do not permit: follow the implications of our ideas to find where they lead and, often, where they are inconsistent. ABMs, like any other models (narrative, formal, or digital), are simplifications. No model captures every nuance of reality, so every model is a caricature. This limitation can also be an advantage. The simplest models are often the most useful, either because they highlight the central variables, or because they show us clearly where our conceptualizations of the problem are inadequate.

Although agent-based modeling was originally developed by computer scientists interested in artificial life, the technique has since been applied to research questions in physics, evolutionary biology, and economics, to name a few. ABMs use software objects called agents that have limited means to perceive some virtual environment and limited repertoires by which they interact with it and with other agents. Whereas the rules an agent follows may be quite simple, the aggregate outcome of their interactions may be difficult to predict. In some ABMs, a single agent interacts with an environment; here, the impacts of varying environmental and/or behavioral parameters are often of greatest interest (Brantingham 2003). In other ABMs, populations of agents interact to form “artificial societies” (Epstein and Axtell 1996) that exhibit emergent properties (e.g., distribution of wealth, variable archaeological assemblages) that are strikingly similar to those in real societies. This kind of modeling breaks free from top-down, deterministic equation-based approaches. The dynamics observed are generated from the bottom-up, in that emergent properties arise

from the individual agents' actions, just as the global properties of a society or complex system emerge from the actions of single persons or components.

Anthropologists can employ ABMs to experiment with the cultural processes that result from various combinations of behavioral rules and selective pressures in the same way that a chemist might experiment with a reaction between various concentrations. For example, *in silico* we can endow an agent with a strategy adapted to one area and observe its success in another: an agent that uses a !Kung foraging strategy can be placed in the Arctic or in a tropical rain forest in a way that a real !Kung forager cannot. Moreover, the most important elements of the model are reduced to simplified essentials, and the state space defined by the entire suite of pertinent ecological, social, and behavioral variables can be explored strategically or exhaustively. Repeatability is a central tenet of scientific experimentation, and provided the input data and algorithms are preserved, every agent-based modeling experiment is completely replicable. Publication of code renders experiments completely transparent as well.

ABMs can encompass large temporal and spatial scales, and yet make many details available for analysis. Consider the utility of a data set that documents the daily movements, interactions, and resulting material correlates of 100,000 people over 1,000 years. Using ABMs allows one to act as an "artificial ethnoarchaeologist" who not only has control over the initial conditions of the model but also has perfect knowledge of every agent's health, memory, individual reproductive fitness, etc. throughout the duration of the experiment. Given this ability to collect accurate data from millions of agents over extended periods of simulated time, ABMs yield richer data sets than archaeologists are normally privy to, and these, in turn, lead to and permit questions that could not otherwise be addressed.

Simulations cannot tell us exactly what happened in the past. But by allowing us to play out multiple alternatives, they provide a way to identify plausible scenarios, as well as to see when our assumptions and expectations lead to implausible or patently false outcomes. They also permit the exploration of multiple hypothetical (what if) scenarios. Such approaches are crucial to the exploration of dynamics in complex and emergent systems, including coupled human and environmental systems.

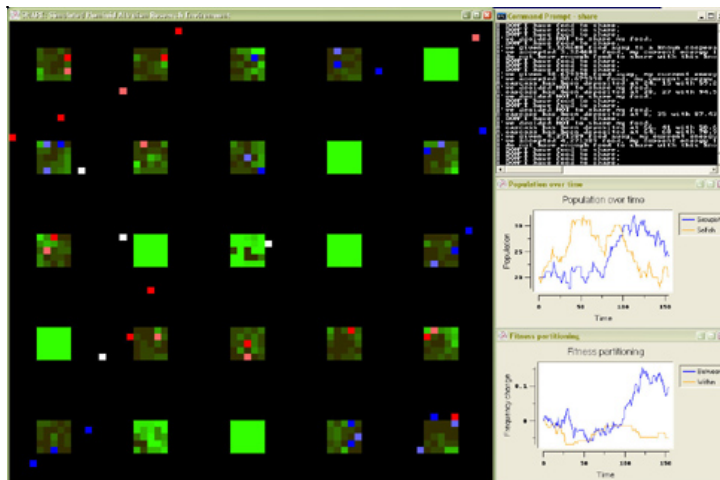
Some Examples of Current Agent-Based Modeling Projects

Luke Premo developed an ABM, called the Simulated Hominin Altruism Research Environment (SHARE), using the Swarm libraries (Minar et al. 1996). The goal of the project is to study the evolution and archaeological implications of Plio-Pleistocene hominin food sharing from the bottom-up. Population data collected from artificial societies of hominin foragers demonstrate that transitional levels of food resource patchiness can facilitate the evolution of altruistic food sharing due to the fitness benefits it bestows upon members of subsistence-related trait groups (Premo 2005). Spatial data collected from artificial assemblages demonstrate that clusters

of dense artifact accumulations, akin to those found in Olduvai and Koobi Fora, do not necessarily require central place foraging; they can form when routed foraging strategies are employed in patchy environments.

John T. Murphy is working with the International Institute for Sustainability at Arizona State University on a model, underwritten by the McDonnell Foundation, of Hohokam irrigated agriculture. Hohokam canals could exceed 20 km in length, but whether the system required a central authority or could have been constructed, maintained, and managed by independent but cooperating groups is unknown. The model includes parameters such as water flow and agricultural production; the simulation assembles data (genuine and hypothetical) on plant productivity, cropping schedules, labor costs, among others. The simulation can be run via the Internet, and forms a "collaboratory" in which Hohokam scholars can work together to construct alternative possible scenarios about Hohokam agriculture and social organization.

Jonathan Scholnick is building an ABM to investigate how different cultural transmission mechanisms affect an artifact style's popularity through time. While archaeologists frequently employ battleship-shaped, unimodal popularity curves to seriate assemblages, the mechanisms that contribute to these patterns have not been systematically investigated. Previous simulations have shown that drift and innovation can generate unimodal histograms (Neiman 1995), but the effect of different learning behaviors on the sizes and shapes of popularity curves has not been studied. Model results will be compared with empirical archaeological data to evaluate the effect that cultural changes such as village formation might have had on patterns of ceramic production in the American Southwest.



Screen shot of SHARE in the middle of a simulation run. Left: altruistic foragers are blue, selfish foragers are red, plants are green, and animal carcasses are white. Each of these agents has its own set of internal variables and behaviors. Upper Right: streaming log of agent communication and agent interactions. Right: line graph of selfish and altruistic forager populations through simulated time. Lower Right: line graph of between-group and within-group selection through simulated time.

Brandon M. Gabler is developing an ABM that will examine emergent aggregation of farming societies on the Pajarito Plateau, New Mexico. This project aims to develop artificial societies on the plateau and follow them through settlement changes due to social and environmental patterns through the Coalition and Classic Periods. The shifts in settlement from low to high elevation are thought to be related largely to environmental conditions, but increased rainfall fails to explain why people remained at high elevations. The promise of an agent-based approach lies in its abilities to generate testable archaeological expectations for different hypotheses about aggregation on the plateau and to facilitate a cross-cultural comparison to determine the robustness of the model's results.

Joseph Beaver is modeling food sharing relationships between households in small-scale farming societies. While traditional approaches to understanding the level of social equality/inequality in such societies treat resource scarcity or abundance as cause or condition, his study examines emergent variability in circumstances of resource-balance at the level of the entire society, but with varying levels and types of inter-household imbalance. Social network analysis techniques are applied to patterns of food sharing relationships to examine the potential ability of households to claim prestige or exercise influence.

Agent-Based Modeling and Archaeological Science

Though the majority of the discipline views the first wave of agent-based applications with an appropriate mix of enthusiasm, curiosity, and skepticism, a distinguished minority has been extolling their potential for some time (see articles in Kohler and Gumerman 2000; Lansing 2003). We believe that agent-based modeling is well-suited to the larger enterprise known as archaeological science. ABMs often involve the application of techniques and theory from the biological, physical, and computer sciences to archaeological problems. In addition, they introduce another fundamental component of scientific hypothesis testing—controlled, replicable experiments—to archaeological research. Thus, a well-constructed ABM acts as a cultural laboratory. It provides a setting in which one can perform experiments that are often impossible to observe in the field. We hope that this brief discussion of the experimental power of ABMs will encourage others to look more closely at this emerging technique—past the eye-catching (but often superfluous) visual displays, around the exotic lines of code, over the stacks of retrievable data, and into the nuts and bolts of the methodology—before (re)considering its rightful place in the discipline.

You may visit the Agent-Based Modeling Group at the University of Arizona webpage (www.u.arizona.edu/~jtmurphy/ABM/ABM.htm) for links to additional resources and lectures.

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References

- Brantingham, P. J. 2003. A Neutral Model of Stone Raw Material Procurement. *American Antiquity* 68(3):487-509.
- Epstein, J. M., and R. Axtell. 1996. *Growing Artificial Societies: Social Science from the Bottom-Up*. The Brookings Institution Press, Washington, DC and MIT Press, Cambridge, Massachusetts.
- Kohler, T. A., and G. J. Gumerman. 2000. *Dynamics in Human and Primate Societies: Agent-Based Modeling of Social and Spatial Processes*. Oxford University Press, Oxford, UK.
- Lansing, J. S. 2003. Complex Adaptive Systems. *Annual Review of Anthropology* 32:183-204.
- Minar, N., R. Burkhart, C. Langton, and M. Askenazi. 1996. *The Swarm Simulation System: A Toolkit for Building Multi-agent Systems*. SFI Working Papers No. 96-06-042, Santa Fe, New Mexico.
- Neiman, F. D. 1995. Stylistic Variation in Evolutionary Perspective: Inferences from Decorative Diversity and Interassemblage Distance in Illinois Woodland Ceramic Assemblages. *American Antiquity* 60(1):7-36.
- Premo, L. S. 2005. Patchiness and Prosociality: An Agent-based Model of Plio/Pleistocene Hominid Food Sharing. In *Multi-Agent and Multi-Agent-Based Simulation*, edited by P. Davidsson, K. Takadama, and B. Logan, pp. 210-224. Springer-Verlag, Berlin.

Book Reviews

Stacey N. Lengyel, Associate Editor

Pompeian Households: An Analysis of the Material Culture. Penelope M. Allison, The Cotsen Institute of Archaeology, University of California: Los Angeles, 2004. xvii + 255 pp., 115 figures, 74 tables, one appendix, index. Price \$40.00 (paper). ISBN 0-917956-96-6.

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