

Evolving Cultural Things-That-Think

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Abstract

Although cultural evolution clearly outpaces genetic evolution in the natural world due to its higher rates of reproduction, recombination and selection, it does so built on biological foundations. In the natural world, cultural change takes place in minutes, days, years or decades, whereas genetic change takes at least a decade and a half. In the natural and cultural worlds the media of evolutionary transmission behave differently: genes reproduce slowly; ideas reproduce quickly. In the artificial world of the computer, whether modeled on a cultural or genetic metaphor, the medium in which evolution unfolds is the same for both, and the generations through which they both unfold is regulated by same the system clock. Consequently, there is no *a priori* reason to assume that cultural processes will be quicker than genetic ones in an artificial world, simply because they are quicker in the natural world. Cultural algorithms may be faster, but if they are it is for more complex reasons, such as their richer combinatorial possibilities (ideas may come from anywhere, zygotes only come from couples having sex), their greater range of generational longevity (from fleeting notions to commandments carved in stone), and the varieties of their modes and units of selection. It seems likely that a science of culture may enrich evolutionary computation by offering a superset of evolutionary mechanisms to explore. Evolutionary computation will surely enrich a science of culture by offering a superset of modeling practices. Such a coevolutionary synthesis may be fruitful to explore.

Natural and Artificial Culture

Empirically, culture is the product of individuals, artifacts, and their interactions at varying levels of complexity. Variation is omnipresent and requires explanation. Cultures are different. Its members are different. Its members' heads are filled with different thoughts. Moreover, cognition is distributed among people and technology. Culture emerges from these objects (thoughts, people, artifacts) through multiagent webs of mutual causation. Cultural processes are parallel and simultaneous. These complexities remain largely intractable to discursive and mathematical representations. The "new sciences of com-

plexity" offer promising alternatives. The practices of evolutionary computation, distributed *artificial intelligence*, *artificial life*, and *artificial society* provide frameworks for multiagent spatial simulations and make complex cultural descriptions possible. This exploration for theory building in anthropology, I call *artificial culture*. (Gessler 1994, 1995, 2003.)

Among the most important contributions of anthropology has been the empirically observable recognition of the pervasiveness of variation, namely that:

1. Cultures are different.
2. The members of a single culture are different.
3. The minds of individual members of a single culture are filled with thoughts that are different.

Thus we see variation in at least three levels of the human cultural domain. But culture includes not just what people are, but what they do. Consequently we must add parallel domains for human behavior and technology. The result is a complex tapestry of multiple causation (multiagency) in which each thread is woven at the same instant (simultaneously and in parallel). Weaving such a fabric is beyond our known technology (though it may be imagined as an elaborate cellular automaton) and yet its unraveling and understanding is among the greatest challenges to anthropology. How do we describe and explain this rich dynamic interplay of objects and processes in culture, much less understand its origins and evolution?

Science might be viewed in the context of the evolution of organic things-that-think. Brains, and what goes on inside them, are selected to provide increasingly reliable representation of the external world that may be used to predict real-world events. If they are sufficiently general, economical and true to real-world actualities, they confer advantages to those who possess them. From this perspective, science may be seen as the formal practice of building increasingly reliable, comprehensive and economical representations of the world. What kinds of representations are the essential primitives of a science of culture?

Discourse, speech and writing, are the *de facto* representational media of anthropology. But discourse has its limita-

tions. Being essentially sentential, sequential and serial in nature, discourse struggles to describe concurrent events. It may narrate events run in slow motion, but surely not in real-time. Mathematics, less popular than discourse, is a quantitative alternative with much to offer, but it too has difficulty with contemporaneous events. Film and multimedia offer rich alternatives in their ability to record and portray complex interactions, but in themselves they do not explain events. Are there representational media at our disposal that may more closely mimic the primitive elements or atoms of culture?

These primitive objects of culture are ideas, people and artifacts. They have their own individual properties and respond to events taking place around them with certain methods of behavior. It is no coincidence that these elements of culture have close analogs in computational object-oriented languages, since these formal languages were designed specifically to represent real-world structures. Thus it would seem that while the description and explanation of complex cultural processes remains intractable to discourse, mathematics and multimedia, by contrast computational representations offer far-reaching and as yet unexplored potential for explanation in anthropology. Moreover, computation offers the necessary flip side to analysis: synthesis. Computation offers the means to automatically reconstruct an entirety as more than the mere sum of its constituent parts. It provides an answer to the engineer's challenge, "If you think you understand it, build me one and show me how it works." *Artificial culture* is an experimental platform for evaluating theory, for studying "what if" scenarios, and thereby separating what is possible from what is not. Computation and simulation may help to build deeply needed scientific theory in anthropology.

Ideas, and other atomic particles of human culture, often seem to have a life of their own – organization, mutation, reproduction, spreading, and dying. In spite of several bold attempts to construct theories of cultural evolution, an adequate theory remains elusive. The financial incentive to understand any patterns governing fads and fashion is enormous, and because cultural evolution has contributed so much to the uniqueness of human nature, the scientific motivation is equally great. (Taylor & Jefferson, quoted in Gessler 2003.)

Key to the conception of an *artificial culture* is the notion of multiple concurrent causation, or simply multiple agency. Agency may be extended from the individual to apply to culture at various scales. We may speak of agents of the mind (Minsky 1985) – competing beliefs and ideas that vie for privilege in a single person. We may speak of human agents – each agent representing one individual. We may speak of agents as corporate groups. Inanimate objects are also agents in this sense, as are artifacts and natural objects of the environment. The concept of the agent is close to the concept of a class or object in an ob-

ject-oriented programming language. Consequently, agency at different scales in culture may be readily described in multiagent object-oriented languages.

Understanding the bottom-up and top-down exchanges between local and global levels of a complex system as each provokes emergences and constraints upon the other is the "holy grail" of *artificial life* research. So too is it in sociology, anthropology and *artificial culture*.

(Multiagent systems) have attained a level of maturity where they can be useful tools for sociologists... (They) provide new perspectives on contemporary discussions of the micro-macro link in sociological theory, by focusing on three aspects of the micro-macro link: micro-to-macro emergence, macro-to-micro social causation, and the dialectic between emergence and social causation. (Sawyer 2003)

The situation is even more complex. While shared meanings are an essential element of culture, they are necessary but not sufficient to explain the totality of cultural behavior. Among shared concepts there is ample room for individual divergence and this disagreement in meaning oftentimes is the animating factor in negotiations and the unequal flow and quality of information (and disinformation). Culture has been described as an organization-of-diversity:

Culture shifts in policy from generation to generation with kaleidoscopic variety, and is characterized internally not by uniformity, but by diversity of both individuals and groups, many of whom are in continuous and overt conflict in one sub-system and in active cooperation in another. (Wallace 1961: 28)

We are not fully slaves to the languages or non-articulated symbol systems that they generate and use. We recognize and distinguish many more differences in objects and behaviors than there are words or symbols to describe them. In natural language this is evidenced by the use of metaphor and modifiers that push or pull meanings in one direction or another. Arguably, a language system sits atop layers of other symbol systems. It might more generally be called one representational system among many others. Recalling the definition I proposed earlier, "Science is the formal practice of building increasingly reliable, comprehensive and economical representations of the world," interaction with the world is the selective agent of science. Human cognition, whether biologically or culturally determined, may be likened to a myriad of representations, metaphorically a hall of mirrors, a set of nested Chinese boxes or Russian dolls. But the structures connecting these representations may not be so neatly packaged. Each may be in a continual state of flux and intermediation. Models of much more complex cognitions have been proposed by computer scientists. Minsky invokes a cultural (or as he calls it a "societal") metaphor of how the mind works. He

proposes that mind is a microcosm of society itself, with mental agents voting to translate sensations to behaviors, and consciousness sitting as an epiphenomenal observer, and unjustifiably taking all the credit.

We'll show that you can build a mind from many little parts, each mindless by itself. I'll call "Society of Mind" this scheme in which each mind is made of many smaller processes. These we'll call *agents*. Each mental agent by itself can only do some simple thing that needs no mind or thought at all. Yet when we join these agents in societies --- in certain very special ways --- this leads to true intelligence... One trouble is that these ideas have lots of cross-connections. My explanations rarely go in neat, straight lines from start to end. I wish I could have lined them up so that you could climb straight to the top, by mental stair-steps, one by one. Instead they're tied in tangled webs. (Minsky 1985: 17)

Rodney Brooks takes a similarly tangled view. He has argued that intelligence and representation are not necessary for purposeful action in *artificial life* forms. By re-examining the roles they play he reconstitutes them on a different level of meaning. He contrasts two models of what might comprise intelligence:

The so-called central systems of intelligence... (are) perhaps an unnecessary illusion... (Perhaps) all the power of intelligence (arises) from the coupling of perception and actuation systems. (Brooks 1999: viii) The basic idea (of the first model) is that perception goes on by itself, autonomously producing world descriptions that are fed to a cognition box that does all the real *thinking* and instantiates the real *intelligence* of the system. The thinking box then tells the action box what to do, in some sort of high-level action description language. (The second model) completely turns the old approach to intelligence upside down. It denies that there is even a box that is devoted to cognitive tasks. Instead it posits both that the perception and action subsystems do all the work and that it is only an external observer that has anything to do with cognition, by way of attributing cognitive abilities to a system that works well in the world but has no explicit place where cognition is done. (Brooks 1999: x)

Anthropologist Edwin Hutchins further extends these modules of intelligence, entangling them with the complexities real-world materiality. For Hutchins, the artifactual, architectural and physical environments are key players in a distributed cultural cognition:

I hope to evoke... an ecology of thinking in which human cognition interacts with an environment rich in organizing resources... It is in real practice that culture is produced and reproduced... I hope to show

that human cognition is not just influenced by culture and society, but that it is in a very fundamental sense a cultural and social process. To do this I will move the boundaries of the cognitive unit of analysis out beyond the skin of the individual person and treat (it) as a cognitive and computational system. (Hutchins 1995: xiv) Humans create their cognitive powers by creating the environments in which they exercise those powers. (Hutchins 1995: xvi)

These computational views of culture comprise a challenge to both social science and computation. The anthropologist may wish to explain culture through advanced computational modeling. The evolutionary computists may wish to design algorithms incorporating the complexities of culture.

A Synthetic Model

Evolutionary computation has been successful in a wide variety of fields, from creating innovative design in the arts and engineering to understanding the complexities of physics and astronomy. The life sciences have benefited too, and have inspired new models of hierarchical selection. In social science work has just begun: Axtell and Epstein made an exemplary start with *Sugarscape* (see Gessler 1996) and Robert Reynolds pioneered work in *cultural algorithms* (see Gessler 1998). I seek to bring anthropology into a partnership with *computational synthesis* by outlining a project to extend the trajectory from *artificial intelligence* through *artificial life* and *artificial societies* towards *artificial culture*. I will suggest a synthesis of knowledge within which culture is constituted as an evolving thing-that-thinks. I wish to investigate the emergence of cultural strategies from a heterogeneous mix of human players, spatially engaged with one another and their material surroundings, in their quest to attain a multiplicity of domain independent goals. Within a system such as this, synthesis necessarily crosscuts several scales of analysis and competing representational realms.

Our Universe is synthesized "from quark to quasar" as lower-level algorithmic processes coalesce to generate higher-level emergences. They too, in turn, are captured and used as primitives at more greatly elevated scales of complexity. This hierarchy, though synthesized from the bottom-up, also enables local properties to be re-formed by top-down global interactions. Situated somewhere along this hierarchy we find our own biology, thoughts, behaviors and technology, which together we call "culture." Human "ways of knowing" are a cultural enhancement of a naturally evolved process of computation through which an organism secures its adaptation to the world. In between sensation and behavior information is processed and re-encoded. Whether learned environmentally or genetically induced, this re-encoding is shaped by natural selection. Between the boundaries of "in" and "out" is an entangled process that we identify with intuition, thought, ideas,

models or cognitions. Each re-encoding of reality literally re-presents the world in a different medium, each medium conferring its own advantages and limitations (such as durability and plasticity) to the process. These intermediated representations thrive within the individual and collective, as well as in material technology and the natural world. Science, in this view, is the conscious human practice of improving these re-encodings, of making representations more powerful, comprehensive and reliable. We need hardly be reminded that *evolutionary computation* is a technological instantiation of a complex natural process, and that by means of this technology we can not only describe our world, but also synthesize its entailments. While anthropologists are well aware of the creative power of evolution, they are largely unaware that its power has been harnessed for computation. Like much social science, anthropology relies heavily on discursive models and remains largely innumerate and incomputational.

Arguably the most important empirical observation about human culture is that it is comprised of individuals co-adapting with their neighbors, technology and the natural world. Describing, much less understanding, the temporal and spatial complexity of these parallel but interconnected realms has been virtually intractable to discursive and mathematical explanations, leading anthropology to focus on elucidating, “shared ideas and beliefs” as the defining elements of culture. Real differences are blended into abstract aggregations. While the quality of being shared is a necessary animating factor in human affairs, it is not sufficient in itself to account for the intricacies of cultural dynamics. Alas, ethnography is often silent on conflicts and their resolution, on selective flows of information (purposeful misinformation and disinformation) and it often totally ignores material technology and the use of space. There is an absence of evidence for complex human interaction in ethnographies, but this omission in the literature is not compelling evidence for its absence from culture. We often do not see what we are not prepared to see. If we were to grow a practice of constructing and exploring *artificial culture* through “what if” experiments, we might redress some of these omissions. A first step would be to treat “culture” not as an abstraction, but to redistribute it among the individuals and objects that we empirically observe. Culture is the structured complex of multiple, concurrent, conscious and unconscious perceptions, beliefs, goals, plans and actions embodied in individual minds, of individual persons collected into groups, and of their interactions with one another and the material world of artifacts (technology) and nature. These are the empirically observable building blocks of culture, the real raw materials and primitives of a *distributed cultural cognition* (see Hutchins 1995).

A model is being constructed to evaluate the interrelationship among a suite of a variety of arguments explaining trading preferences.

The question of why hunters target large game knowing that most of the meat will end up far beyond their own hearths is an intriguing one. It raises the issue of whether foragers pursue nonnutritional goals in food procurement and which goals they pursue. (Wiessner 2000: 407.)

Abstract questions will be investigated along with concrete questions based upon empirically derived ethnographic information from among the !Kung hunter-gatherers of the Kalahari desert. These hypotheses include reciprocity, costly signaling, nepotism and long-term political goals. Alternative scenarios will be run with over 60 years of demographic data and extensive notes made in the field in collaboration with Polly Wiessner. The model will also provide an experimental platform for testing less empirically supported claims about the functioning of kinship systems. In this context it will explore the claim that they evolved in order to reduce the cognitive load on (and increase the computational efficiency of) individuals, enabling them to keep track of a small number of kin, rather than keeping track of everyone. To these ends, an *artificial culture* has been seeded with a population of individuals. Each has the property of age, sex and parentage, and each is situated discretely in both space and time. Each has four potentially competing goal domains: food, shelter, protection and reproduction, which in combination constitute its fitness. Each goal can be met only by negotiating transactions with different sets of individuals. Goals are attained through the implementation of different strategies, which in turn are synthesized and mediated by evolved beliefs and plans before becoming actions, which have observable behavioral and material consequences. Beliefs and plans arise from the perceptions of the local environment mediated by evolved categories. These beliefs include basic kinship nomenclature (with its associated privileges and obligations), and also the *theories of mind*, behaviors and credit ratings of other individuals. Beliefs may be observed either first-hand or acquired from other individuals by exchange, in which case the source of that information is noted. Each goal domain is allowed to evolve separately, and associated beliefs, strategies, plans and actions for each domain remain distinct. Stress within each domain, arising from cooperation and competition, will be calculated with a payoff matrix similar to the *Prisoner's Dilemma*. This structure, as simple as it is, should produce complex interactions within and among these distinct domains as characteristically different representations come into play. It should also provide a framework in which the supposed role of kinship systems in human culture may be investigated, although we may find that its origins may not lie solely in the realm of record keeping. They may include psychological bonds genetically prescribed or procedures for commending cooperators and retaliating against or deterring defectors. While the simulation keeps domains distinct, it does allow emergences to crosscut their boundaries and thereby may build modular

structures by analogy. This is a powerful way in which humans deal with novel situations.

Seeking modular interrelated goals in a population utilizing a diverse mix of cognitive and material representations and intermediations should shed new light on hierarchical synthesis in both anthropology and computation. When these are embodied among a heterogeneous population where transactions require negotiations between partners who are not equal with respect to how each person seeks to maximize his total fitness, new insights may emerge.

Conclusions

In anthropology, computational modeling is an effective way to describe and test hybrid systems of ideational, material and biological causation. In truth it may be the *only* practical way to describe and test such complex systems. If we view science as a way of building increasing reliable, robust, comprehensive and economical representations of the world around us, then the new descriptive languages of computation along with their narrative entailments offer us a challenging new medium in which to conduct our research. As social scientists, we should create and calibrate these artificial worlds until they closely match their natural world referents. This may be difficult because the simulations often imply processes that we do not see in ethnographies. Experiments with *artificial culture* can provide new insights and set limits on the range of explanations possible for real world *natural culture*. It may well be that the only way to explain a culture is to model it. The proof of the validity of an *artificial culture* model could be a modification of the Turing test. The degree to which the objects and processes of an *artificial culture* matches those of a *natural culture* seen through the filters of different descriptive renderings, could be taken as a measure of the model's cultural validation, or "culturicity." If the observer, screened from seeing the flesh-and-blood and chips-and-boards of the natural and *artificial cultures* competing in the test, but able to see their larger behaviors, cannot distinguish between them, then as Turing would claim, the simulation is itself a culture.

Modeling the distributed nature of the mind, the individual, and artifacts seem to me to be the central challenges of anthropology. Culture is present in all three and indeed it is a thing-that-thinks in all three levels. Modeling these, situated in space and time and materially embodied, offers distinct advantages over the traditional descriptive and explanatory tools we encounter in the media of discourse, writing and mathematics. It offers clarity of construction and a seed that can be nurtured and grown to spin out and weave new entailments as experimental histories and narratives.

Artificial culture is part of a new research paradigm. Its formulation combines epistemologies of both evolution and computation. It is from the perspective of the new sciences

of complexity that the definition of scientific practice, that I cited earlier, emerges. Acknowledging the foundational assumptions of any new theory of knowledge is a vital enterprise. Unexamined empiricism is as blank as the slate that it assumes. Without knowing what is at stake, one can only see what one expects to see. This is why philosophies developed for the media of discourse and mathematics are limited in what they can tell us about computation. The absence of evidence for a new phenomenon does not sufficient evidence for its absence. Discoveries are discoveries precisely because what they discover has never previously been seen. We cannot look at computation through traditional eyes.

If one projects the historical trend along the trajectory beginning with distributed artificial intelligence to the development of *artificial life* and *artificial societies*, it is easy to foresee that the next focus of attention will be with *artificial culture*. It is their next grand challenge. To accept that challenge, we must form alliances with evolutionary computation. We must recognize the power that has been harnessed in evolutionary software, firmware and hardware. After all, evolution is what created us. Now we have re-created it in our machines.

As social scientists, we need to develop fluency in expressing our thoughts, observations and processes in an object-oriented language. Doing so will heighten our perceptions, enabling us to recognize the essential elemental objects and basic processes at play in natural cultural phenomena. We need to train ourselves to be cultural simulation programmers, not simply users of simulations. Only in this way can one begin to think in terms of multiple agency. To think in multiagent ways is to see multiagency at play.

As scientists, we are drawn to climb the highest hill in order to gain the greatest objectivity and perspective. We metaphorically wish to reach the summit of the gods and from that vantage point take in the grandest view of all: the view of everything from nowhere in particular. But in the real world such a view of culture is impossible. It would require the anthropologist to be all knowing and everywhere at once. Instead, we might try a more practical approach. Why not make a transparent model, shrink it and put it in a box? Metaphorically, that is the task of *artificial culture*.

In this minimal world it should be possible to investigate the origins and management of competition, cooperation and risk, the assignment of credit ratings by individuals for other individuals, trade in information and resources, trade in information about information and resources, selectively distributed information, misinformation, disinformation, computational efficiency, cognitive load and even the behaviors of alternative representational strategies and schools of scientific thought. We should bear in mind that emergence presupposes that any model of cultural com-

plexity can give rise to a more general model at a level above, and a more specific model at a level below. Consequently, a multiagent society may be comprised of multi-agent minds, in multiagent individuals participating in multiagent group activities.

Just as the logic of a discursive argument must be made transparent to the reader, so too the code, algorithms, objects and processes of a simulation must be equally exposed. Without this clarity, the argument and the simulation are merely opaque appeals to authority. True conversations with simulations require dialogues with intelligent machines. In developing “tools to think with,” we must be prepared to spread their parts out on a conference table for discussion. This means developing highly visual applications, complete with commented source code, downloadable from the Web, and an active program of building applications.

In the middle of the 19th Century we discovered evolution through natural selection. In the middle of the 20th Century we discovered how to build machines that think. At the beginning of the 21st Century we are beginning to fully recognize the importance of evolution in shaping our bodies and our minds, our societies and our cultures. We stand at the beginning of a new era, in every way as consequential as the Industrial Revolution. Ours is a revolution of both technology and thought. Evolution is our creator. We have captured our creator and placed it, like a genie in a bottle, into our machines. Through our conversations with colleagues and our conversations with machines, we are beginning a strong collaboration in pursuit of the deep nature of cultural things.

The desire to have the actors in an *artificial culture* redefine the system in which they are a part is a current research challenge in evolutionary computation and is the subject of a forthcoming conference on “computational synthesis.”

Computational Synthesis research seeks formal algorithmic procedures that combine low-level building blocks or features to achieve given arbitrary high-level functionality. The main challenge is scaling to high complexities, and the paths of investigation deal with automatic composition of building blocks into useful modules, automatic abstraction of module functionality, and automatic hierarchical reuse of modules. The symposium will focus on domain-independent methods that address modularity, regularity, hierarchy and abstraction in automatic synthesis. Recently there has been a surge of interest in these fundamental issues from three directions: AI researchers interested in scaling discovery processes, engineers interested in fully automated design, and biologists interested in the origin of complexity. (Lipson 2002)

All these elements are at work in culture, and it is culture that has set us on this quest. Just as culture was synthesized from biological elements, so too might we find that culture may inspire robust algorithms for hierarchical synthesis in evolutionary computation.

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