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Introduction

Formalization is typically associated with an emphasis on form over content or meaning by both supporters and detractors of formal methods, however well founded, this association fails to capture why we employ (or not) formal descriptions of what we are describing.

One problem arises when we try to directly link human thought to human behavior (or vice versa), even assuming the process of going from one to the other is complex and perhaps idiosyncratic but direct. In this paper I discuss an approach to developing a formal system that helps us represent the relationship between ideational and behavioral aspects of socio-cultural phenomena in a manner that is consistent with, and helps address the connections between, symbolic and materialist approaches.

People embedded in cultural processes demonstrate remarkable powers of creation, transformation, stability and regulation. Culture gives agents the power to hyper-adapt: not only can they achieve local minima and maxima, they modify or create the conditions for new adaptations. Culture transcends material and behavioral contexts. Cultural solutions are instantiated in material and behavioral terms but are based in large part on 'invented' symbolic constructions of the interaction space and its elements.

I discuss these issues and present an example of how a symbolic system 'drives' the material organization of human groups, explore how symbolic systems act over material domains as a general case, and examine some of the implications of this for multi-agent modeling as a theory-building process.

Development of the Culture Concept

Anthropologists have proposed a vast number of definitions for culture over the past century. The definition of the 'culture concept' over this time has shifted from almost exclusively behavioral criteria (c.f. "... that complex whole which includes all the habits acquired by man as a member of society." Ruth Benedict 1929) to a focus on ideational and symbolic criteria (c.f. "... a system of symbols and meanings." David Schneider 1976). This shift represents development in anthropological theory as well as the impact of systems theory.

Culture as a systemic concept has rapidly become pervasive outside anthropology in many cognate social sciences and humanities subjects, and increasingly in primate studies (but with considerably simpler criteria c.f. McGrew 2003). Despite this anthropologists are generally unable to define precisely what is meant by culture. One explanation for difficulty in definition is that culture is not defined by a single process or system but is the conjunction of many aspects of human cognition and organization (Leaf 2005). These would include processes or systems relating to communication, learning, adaptation, representation and transformation. In short, what anthropologists, and increasingly others, now refer to as culture is an emergent phenomena (or perhaps even an apparent category of phenomena) – the result of interaction of different systems which are, at least in part, independent of each other (Chit Hlaing 2005).

Since the mid-1960s the trend in social and cultural anthropology has shifted from a focus on behavior to meaning, using approaches ranging from cognitive to interpretive. We also see a shift in focus from structure to process, with many anthropologists expand-

ing this to consider direct interpretation of experience, embodiment and meta-facts relating to the ethnographer in the ethnographic context.

Culture as a theoretical construction has moved somewhat from the foreground to the background across the range of anthropological approaches. Some anthropologists have questioned the culture concept itself. Is culture nothing more than a conventional label that other anthropologists apply to a particular set of processes and objects they have selected? Are we describing anything other than these selected artifacts? Can this same logic be applied recursively to the content of that which was formerly called culture? For some anthropologists kinship is thus deconstructed into an analyst-selected set of relationships. Poetry, mathematics, science and arts are similarly so subsumed. Culture is conceptualized as the arbitrary end result of a lot of people interacting with each other.

While this is far too extreme a position, an interrogation of the culture concept is necessary. One problem is that culture is often described from a top-down perspective to understand individual acts as if they were a direct production of 'culture'.

Murray Leaf [2008: NSF Grant Proposal PD 98-1390] writes,

> It might be argued that the idea of overriding cultural and social unities is already dead, and has been since David Schneider's explicit rejection of the idea of "total system models" in favor of "partial system models." ... but ... partial system models were only a total system writ small ... The fundamental problem with total system models was ... [that] such unity could not be observed, it had to be imputed. ... the justification was always some version of Durkheim's idea of a "social fact" as opposed to a fact in an experimental sense. A social fact is a fact required by social theory alone, not by what is actually evident. ... there could be no definitive relationship between theory and actually available evidence, and conversely no provable relationship between any particular observation and what was expected to flow from it. Eo ipso, there could also be no solution to the problem of going from observed decisions and actions at the individual and organization level to provable (non-circular) calculations of their emergent or aggregate effects.

We can instead assess culture from the bottom-up, not as a set of rules but as capabilities and resources people use to address common and idiosyncratic problems and situations. In particular, culture can be framed as a kind of 'ideational technology' that is critical to defining and building the world in which people live.

Cultural systems must in part consist of knowledge and processes that:

1. maintain and distribute 'high-fidelity' knowledge in a population of agents
2. produce the conditions by which cultural knowledge is useful
3. set the terms of reference within which behaviors or actions take place

Ultimately these must all be instantiated by people as behavior; but in a given situation the relationship between behaviors and other material elements does not appear to be direct. Although we can often identify statistical relationships associating elements, all this really gives us is evidence for a reduction of degrees of freedom in that situation. We have no real explanation of the mechanics underlying the association or the variation in the association. If we are to make progress in sorting out the mechanics of culture, we must take an approach that allows us to relate the instances of behavior, judgments and

productions that we can directly or indirectly observe to hypothetical generators for these instances.

Changing Cultural Theory

Murdock argued that culture was "superindividual ... beyond the sphere of psychology .... It is a matter of indifference to psychology that two persons, instead of one, possess a given habit ... it is precisely this fact that becomes the starting point of the science of culture" (Murdock 1932:207). When the concept of a system became available in the 1940s (D'Andrade 1995), anthropologists were able to progress their framework considerably as they now had a language for describing the relationship between complex unseen systems of thought and the expression of these as behavior. Behavior could be conceptualized as an inscription of individuals interacting, driven by complex systems of thought.

Murdock (1971) later argued that culture cannot be represented in terms of uniform static structures; culture is dynamically enacted and constituted differently by different culture-enacting agents but with results that are comprehensible, if not acceptable, to other agents:

> G. P. Murdock, in ... "Anthropology's Mythology", argues that neither culture nor so-cial structure can be reified to serve as an explanation. Rather these are our characteri-zation of patterns of interactions between individuals, not the source of these interac-tions. ... Murdock was introducing a program ... focusing ... theory on diversity of indi-vidual experience and choice, not commonality and conformance. — Fischer and Lyon (2004) on Murdock (1971).

It is critical that we understand how cultural systems become distributed within a popula-tion in such a way that sufficient agents can agree on what is cultural and what is idiosyncratic, or at least what they can make cultural. To connect a diverse community of minds culture must be relational; different agents will behave differently based on their relationship to other agents. Culture is enacted differently by different cultural agents, each of which has an understanding of how the other agents operate under different projections with respect to different relation-ships (Hutchins 1996).

Fischer (2005) relates some of the context for how implicit and explicit theories of culture have changed in recent decades, in particular the tensions between those who see structure and pattern and those who deny these in favor of performance, improvisation and idiosyncratic emergent culture. Fischer observes this tension is resolved if we recognize that not the least of the outcomes of cultural processes is to recreate the conditions for cultural technologies of thought and objects to operate, symbolically and materially.

Cultural systems of knowledge do not just facilitate people exploiting or adapting to the world around them and maintain the knowledge and practice necessary to recreate the condi-tions required for people to apply cultural knowledge. Cultural systems of knowledge also fa-cilitate the incorporation of human invention - changing the world to create new capabilities and institutionalizing these changes which themselves serve as the basis for developing yet more capabilities. If we conceptualize the core of culture as more about the production of capa-bilities of which rules, codes and behaviors are artefacts, then we have a base that can support most approaches to cultural theory and analysis. I am not attempting to revive a functionalist framework. Rather I am arguing that through cultural systems people as much drive the world

around them as adapt to it - adaption is largely mediated by culturally maintained changes through the use of culturally maintained capabilities. Thus pattern and structure emerge - we do create a particular range of circumstances through culture - but we have the capacity to shape these circumstances through creative use of capabilities and not simply submit.

From this context Fischer develops 'powerful knowledge', cultural knowledge that is pragmatic, creating and enabling the management and exploitation of the multiple possibilities that emerge from interacting cultural agents and their knowledge of cultural domains. Fischer (2005) argues that cultural domain knowledge is evaluated in terms of being enabling or effective – it only need work. Anderson's (1996) analysis of cultural ecology is consistent with this account (for example, humoral medical systems (pp. 50-1)), and the identification of animals with people and their incorporation into the social world (pp. 57-9)). Cultural knowledge can be described using deontic modality[1] in the modern sense (Maibaum 1986), corresponding to a logic including modal operators for representing and evaluating non-monotonic (provisional or defeasible) reasoning, in particular the identification of what is required to permit or restrict subsequent application of capabilities.

Abstract truth values are secondary with respect to application of knowledge, particularly since there are usually many alternatives, though success and failure may be stated in terms of truth value. Transforming information or experience into knowledge is a role associated with culture but people embedded in a culture have many ways of carrying out these transformations. An understanding of culture cannot be derived from treating an instantiation as if it were an underlying principle. Indeed, I suggest that when looking at the level of instantiation (in the sense of Read 2002) it is both plausible and likely that underlying principles often cannot be expressed in a context of contingent events.

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[1] Deontic operators are modal logic operators which express permissions and obligations. The operators most used are of two basic types, permission (per) and obligation (obl). The operators have a precise formal meaning. An example of the use of permission is:

Thus for example we might express a few axioms of Gilbertese weather forecasting (Lewis 1978):
   fine_weather -> per(Islander, make_long_voyage)
   bad_weather -> ~per(Islander, make_long_voyages)
   blocks_hole(Crab) -> [Crab, scratches_sand_flat] bad_weather

The basic advantage for modelling people using cultural resources is that descriptions need not entail specific actions but focus more on potential actions and outcomes by indicating the constraints and enabling factors relating to a system. This in turn provides a useful basis for exploring decision processes in dynamic, changing, contexts.

See Fischer (2006b) for use in analysing ethnographic cases and Fischer and Finkelstein (1991) for a discussion of deontic logic in conjunction with ethnographic description. For an extended description of deontic logic see the *Stanford Encyclopedia of Philosophy* entry, McNamera (2008).

Instantiating Ideation

A population that uses diverse symbolic knowledge can apply that knowledge in a dynamic manner to solve new material problems. There are adaptive advantages to having a distributed and diverse knowledge environment both for the population as a whole and the individuals within it, even those that are themselves less adapted. Even in a highly constrained environment with somewhat unforgiving evolutionary forces at work, cultural systems require more than one type and distribution of knowledge to learn and adapt.

Fischer and Read (2001) outline an approach to focusing on culture in a way that the duality between ideation and behavior can be represented in concrete models. The basic concept is simple; that we can represent culture as a collection of discrete symbolic systems, possibly not logically consistent with each other (following Leaf 1972). These systems of symbols are 'shared' between agents to varying degrees of detail and consistency. It is when agents instantiate these within a common interaction space into a set of behaviors that commonalities are formed and inconsistencies are reconciled. Indeed, the patterns of behavior that are recognized as culture may emerge from underlying symbolic systems that are apparently at odds with each other, both within the same agent and between agents.

In the crudest terms an instantiation of an ideational system is the production of an instance of behavior conditioned by an ideational system within a given material context (Read 1989), which may include other agents each instantiating the same or a different ideational systems of their own – the reduction of the possible to a presence. Instantiation is an interface between ideas and action, conception and creation, thinking and doing. Models embedding both material and ideational themes are important if we are to advance our understanding of human lives embedded in the world. Many of the problems anthropologists investigate relate to an ideational structure or process embedded within a material context (or vice versa).

Ideational models are critical in human groups to support hyperadaptation (Fischer 2005). Hyperadaptation refers to processes which actively modify the environment so that other adaptive or hyperadaptive processes can be enacted. Cultural hyperadaptive agents use a 'story' to go with the actions that replicate the conditions for hyperadaptation. The critical feature the story must have is that it is logically consistent, otherwise it is difficult to transmit with fidelity within a group. If the story can be reproduced with fidelity this helps to stabilize the associated knowledge of technique and translation (instantiation) necessary to produce behaviors from the story.

It is the behaviors that actually produce the effects that agents have adapted to. Instantiation is the process of translating these 'stories' to actions – 'powerful knowledge' (Fischer 2004, 2005). Powerful knowledge changes more easily (and necessarily due to the need to adapt) than the stories. Other, non-cultural, agents also adapt to the changes that hyper-adaptive agents introduce. This includes both other humans (in other groups), as well as members of a group, and other 'species' of agent altogether. This is in part a consequence of the need to distribute 'expertise' that is necessary to maintain the hyperadaptive invention.

It is difficult for us to evaluate ideational systems in isolation. Behavioral processes are difficult for us to interpret. If we embed material and ideational components within an integrated model, the properties of ideational systems and observable indices of these in behavior may be identified. We can create models that both take account of how the physical context limits the

application of ideational resources and how ideational resources influence the structure and re-creation of important aspects of the physical context. Considering ideational resources in the context of their application solves many of the philosophical problems that arise when considering the ideational or material issues alone (such as infinite regress, reflection, [non-] determinism, [non-] essentialism). Although there are a large number of ways for an ideational resource to be instantiated in a given material context, these will generally be far fewer than the number of ways in which these can be imagined to instantiate. Additionally, the same basic ideational resource can/will be instantiated differently in different contexts.

In modeling instantiation, we represent a group of people as a collection of individual agents, not an abstract aggregate. This makes it possible to study why and how patterns emerge, which cannot be done if we only consider the aggregate that exhibits the pattern. Instantiation is a process that mediates the mapping from ideational structures to physical effects. Behavior is not a direct result of ideational systems but of the 'rules' of instantiation of an ideational system. Cultural schema need not be directly linked to behavior, nor need they be functionally dependent on 'what works', at least until a system of instantiation can no longer reliably connect cultural schema to material requirements – a condition that we posit is relatively infrequent until the possible instantiations become redundant or low-valued. Thus cultural schema can be relatively stable and conservative while being adaptive to context and supporting relatively rapid adaptation by modifying the pattern of instantiation rather than the pattern of fundamental ideas and thought. Also, instantiation occurs whenever idea contacts the world. The result may stem more from the external context than from what was 'intended' or 'desired'. That is, cultural instantiation is a process of ideational principles of multiple agents interacting together, often within a material context. The result, whatever it is, is the instantiation. Agents rarely fulfill their goals in full, and sometimes not at all.

Instantiating Cultural Systems

Read (2006) explicates our use of instantiation in research on a universal cultural domain, kinship terminologies. In the course of developing a computer program, Kinship Algebra Expert System (KAES[2]) (Read and Fischer 2004), to assist in the production of algebraic models of the structure of kinship terminologies we made a number of important discoveries. Roughly following Wallace and Atkins (1960) but more precisely, Leaf (1971), a kinship terminology can be represented entirely in terms of native thinker judgments of the relationships between terms without reference to external genealogical concepts (Read 2006).

KAES identifies an underlying algebraic structure for this representation of the terminology (if there is one ... so far all complex terminologies we have tried are amenable). Based on graphical input relating to a given kinship terminology and knowledge about the relationships between terminologies (in terms of the terminology only) produces results that can be instantiated in a given real or model population, based exclusively on internal properties of the kinship terms, indigenous judgments of lexical properties of the terms and very basic relationships between terms based on entirely internal criteria. Unlike most attempts at formal modeling our

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[2] The KAES program and more information on KAES is available in Read (this issue) and at http://kaes.anthrosciences.net

approach makes no recourse to [hypothetical or real-world] external reference frameworks such as a genealogical grid.

This is not the first model to be based on lexical properties of kinship terms. The componential systems developed in the 1960s (cf. Lounsbury1964, Wallace 1962 and see Leaf 2007) were based on lexical properties associated with kin terms, and were, therefore, formal only in a weak or trivial sense. These did not result in structures which were general because the formal model used had no analytic capacity beyond establishing that the relationships in a given terminology were consistent. Wallace and Atkins (1960), Leaf (1970), and others developed such properties in their relative product models of how instances of kinship terminologies are generated. Fischer (1994) built on a similar foundation to implement a general formal representation of kinship suitable for instantiation; but while formally based, the fundamental properties it depended on were assumed to be given. Other algebraic approaches to terminological analysis have been extant for over 50 years but have either fitted terminologies to prescribed structures, or been difficult to instantiate on actual populations; there was no easy way to relate the algebraic account and the instantiation of kin terms in groups of people. Additionally these systems tended to depend on considerable algebraic creativity and understanding on the part of the analyst and their readers.

Our model is algebraic and algorithmic. That is, the models are algebras, and producing and applying these algebras is done following an algorithm. We have developed a computer program somewhat based on Read and Behren's earlier KAES (Read and Behrens 1990) but, rather than an expert system which assists in making decisions towards creating an appropriate algebraic account, our program generates the algebras directly from the source data (lists of terms and indigenous judgments on relationships between terms), using only a very limited set of user decisions where more than one algebra is possible for a set of algebra generators and base equations. We have retained the KAES label for historical continuity.

Although doubtless a bit abstract, KAES is significant. Most important is the result that is emerging from using KAES: the strong suggestion that most, if not all, elementary and complex kinship terminologies can be described in terms of an algebraic structure. This is significant, because there are many more terminologies possible that do not possess such a structure. That the human mind should produce the more limited set implies some deep commonalities in the forms of logic that humans employ. However, greater significance emerges when:

1. a formal model of an ideational system derives entirely from judgments on terminological relationships, not on an instantiation in a population. (knowledge not behavior)
2. the ideational model contains possibilities that specific populations (e.g., American, Shipebo, Punjabi, Kariera, and Trobriand groups) do not exhibit. (implies limits)
3. this model can be instantiated over a specific population (it is descriptive), and gives results that are predictive of the set of instantiated relationships in specific populations. (it is explanatory)

The KAES framework is a good example of how the results of the analysis of an ideational system can be directly introduced into subsequent models without transformation or 'tailoring' for the purpose. That is, it provides a means of representing the potentialities of a cultural sys-

tem and relating these to specific contexts without performing the reductions a particular context would normally require – reductions are properties of the process of instantiation and the limitations of the domain over which the instantiation is being projected.

One thing that almost all kinship terminological systems have in common is that they must be instantiable to be useful and to reproduce themselves. Being instantiable implies certain properties that an instantiable system must have to 'become present'. Among these is some extent of stability. Most systems can change relatively easily and remain a system. Although it is possible to modify an algebra and have a result that is an algebra, this is much 'harder' to do. Therefore systems that must be stable will benefit if they must also be logically equivalent to an algebra (this would not be unique to algebras but a property belonging to any system of symbols with internally defined rules of production). Beyond this we found that the approach that Read used to identify the algebraic structures underlying terminologies itself could be improved and better understood by taking instantiation into account. That is, by taking into account the need to be instantiable and stable, the algorithm became simpler and more understandable, and this could be used as an evaluation metric for choosing one approach over another. The algorithm resulting from this approach was much more unified than Read and Behrens' earlier attempts; it suggested ways of dealing with terminological systems that had previously been resistant to explanation (classificatory terminologies) and the role and representation of gender was significantly improved.

The most remarkable outcome, from our perspective at least, is that

a) by using a small subset of knowledge about the ideational properties of the terminology – the generating terms and equations for an algebra of the terminology, and using

b) a small subset of the knowledge about instantiation – how the algebra is mapped to relationships between people –

c) the complete structure of a terminology can be generated precisely (Read and Fischer 2004).

That is, the positions for the remainder of the terminology can be predicted from those in the generating terms. To our knowledge this is the first example of a predictive model of a cultural system based entirely on data consisting exclusively of relational judgments between a subset of elements in the system. This result is not possible by looking at the behavioral data (instantiations in populations) alone, nor by construction of an ideational model alone, but only by combining aspects of both in a single model. That is, the ideational model and the instantiation process constrain each other to produce only results that we can observe.

In some ways this returns us to the separation between the analysis of competence and performance proposed by Chomsky (1957). He notes that we cannot simply analyze the structures that occur, because there are 'errors' and little variants that will 'spoil' any formal description. But this is not the real reason.

We cannot analyze narrow behavior because it is only a tiny fragment of what is going on. A given example of behavior is the one of many potential behaviors that becomes instantiated. Contrary to Chomsky's conjecture that separates the analysis of competence from that of per-

formance, the point at which instantiation occurs is critical to analysis from either an ideational or material perspective. Ideational analyses that ignore altogether issues of instantiation cannot account for either the variation or stability in culture, nor can materialist analyses ignore the principles of ideation in the instantiation of practice or behavior.

Changing the World

How do we practically extend this beyond kinship terminologies? We cannot continue down the track that anthropologists followed for some time, where we expect cultural symbolic models to be some kind of representation of reality. This may be the case in some instances but is an unnecessary constraint. In principle, a cultural symbol set can be pretty arbitrary, as long as it has strong internal coherence and becomes associated with some means of transcription or instantiation in some useful context(s). We require strong internal coherence because this makes possible transmission with fidelity which is central to the idea of culture as 'shared'. Symbols in arbitrary relationships will require stronger maintenance mechanisms than those in a logical relationship (Shannon and Weaver 1963, Fischer 2006a). Hyperadaptations require repeated prior effects and thus some mechanism for maintaining these relationships. The symbol sets' internal coherence may be so strong that it can be represented as an algebra but weaker structures can be maintained by associations with other cultural symbol clusters, stories like myths, or other devices.

The important thing is that symbol clusters are a) stable and transmissible with low error rates (or correctable errors), and b) there is some way to instantiate them, either to other cultural symbol clusters or to manipulating the material world (powerful knowledge). The example of kinship term algebras illustrates that the main feature of cultural symbol systems is that they are not a defective or simplified version of the real world that we use as a metaphor to understand reality but rather they contain information that allows us to construct reality by the process of transcribing knowledge in cultural symbols and their relationships onto what we are experiencing, modifying or in constructing that experience.

As cultural symbols change the way we conceptualize elements of the world and what we can do with them singly and in aggregates, cultural symbols modify, literally, the material world, and give a very real meaning to the idea of social construction – not out of 'nothing' but rather out of the symbols' abstract relationship to the elements of the world.

This creates an interdependent relationship between the limits of our experience (what things can do) at any one time and the range of possible operations that can be impacted by symbolic transcription. However, the power of culture is that to a considerable extent it can lead us to modify what the properties of 'real things' are, not in an abstract ultimate sense, but in terms of how things work in the material world as it is. We can modify this material world and its organization to make available properties that did not exist before (e.g., given that they were abstract and un-instantiable in the prior context).

Thus the development of cultural knowledge is not about just creating mental sophistication but also about creating material sophistication, and we can see this by looking at human progress in modifying the world over the past 50k years (or one could use 100k, 500k and 1.5m), where arguably culture must be the main additional human capability that can account for the extent we can modify and utilize the material world.

Although most anthropologists would find this framework a bit 'materialist' for their taste, it is distinguished from other materialist frameworks – in this framework it is the cultural symbols that are dominant, which is the perspective most anthropologists actually work from. Materiality can impose constraints but cultural knowledge can undermine these constraints and create new opportunities.

In this sense we have a formal argument at a level that is understandable and useful in terms of anthropology as it is, not as we would like it, and KAES is an example that drives this idea home (and disposes of many of the ghosts of kinship theory in the process).

Cultural symbol clusters could well be central in providing structure to instantiating knowledge (knowledge that is used to instantiate other knowledge), which is much more varied in quality and quantity and must be much more mutable over time, and is relatively much harder to learn and thus transmit. These cultural symbol clusters are relatively small, and used in conjunction with a lot of other cultural symbol clusters, which creates a lot of possibilities for instantiation/transcription in different contexts.

So we end up with something that might sound a bit like memes but, instead of just describing the fact that ideas are transmissible, we have a means for describing and relating the processes of creation, transmission, transcription and instantiation of ideas: Not quite culture's 'double-helix', but a step closer.

Conclusion: Culture and Multi-agent Modeling

Most of this paper has related a view of how human agents utilize cultural resources to produce technical effects on the environment. This reflects much of my experience with multi-agent modeling, which has been principally oriented to modeling human agents in different social and environmental contexts. Although KAES demonstrates at least one cultural system that is logically equivalent to the framework I have presented, it also demonstrates that we will need new approaches and tools to augment the approaches that are current in investigating culture. Although I would like to advocate that we simply apply similar approaches to KAES and develop similarly predictive algebraic models, it is clear that even if this approach is general enough to subsume most cultural systems, we do not as yet know enough to take this approach. We need a method that permits us to represent our data in as disaggregated a form as is necessary which we can use to evaluate the properties of instantiating symbolic relationships.

Multi-agent models are one tool that is promising[3]. These permit us to combine a distributed view where individuals and groups can be represented as individual agents, each with their own knowledge, behaviors and needs and associated plans of action. Early examples of computer modeling in anthropology (e.g., Kunstadter et. al. 1963; Coult and Randolph 1965; Gilbert and Hammel 1966; Randolph and Coult 1968) used a multi-agent approach (well before this concept was used in most other disciplines), and I applied it massively in my 1980 MA thesis to simulate a village based on over a decade of research by Henry Selby and his associates and students. Here, the agent motif was extended (rather over-enthusiastically; but see Christiansen Altaweel 2006) even to individual cows, pigs and corn plants.

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[3] Some basic examples of and commentary on multi-agent simulations are available at http://lucy.kent.ac.uk/Simulate and at http://era.anthropology.ac.uk

Does the approach described in this paper have anything to offer to improve our use of multi-agent modeling in general, particularly for the building of social and cultural theory? Kuznar (2006) argues that multi-agent modeling is a theory-building tool rather than simply being a method to mechanically implement models based on other theories. In other words, the logic and semantics of multi-agent modeling are strong enough to build theory. Or perhaps, more pragmatically, the models we implement using a multi-agent framework are limited by the discipline of the framework in a manner that leads to explanation rather than exclusively description.

Better forms of description are often linked to advances in theory. The main issue is what is 'better'. Simply representing our subject with a more detailed description, while it might allow us to describe in better detail, does not in and of itself lead to better theory. Indeed, if the new description is not amenable to identifying interrelationships among elements of the data, and thus some reduction in the possibilities, it may not support the production of theory at all.

We can generally say that a description promotes theory if in conjunction with the theory we can produce a more detailed description from the simpler one. That is, we evaluate theory by identifying its capacity to reduce the complexity of another description while being able to recreate that complexity without losing information or by being able to demonstrate that information lost was of minimal importance with respect to what the theory is attempting to describe or explain.

Multi-agent modeling appears to meet this criterion. While we are describing the constituents of a situation in rather more detail than is normal by avoiding aggregation, we are describing how these constituents interact with each other to produce what appear to be complex phenomena. If this complexity is reasonably congruent to the observed data (within some level of statistical measurement), then we have produced evidence that the multi-agent model may be regarded as logically equivalent (within some statistical limits) to whatever processes produced the observed data.

Paul Ballonoff, in a private communication commented:

> What (does) "agent theory" (do) which was not already done (theoretically) in the 1940's by Leontief technical coefficients, and which therefore is limited for the same reason: it ignores the dynamics of possibly changed preferences and the possibility of "technological progress" and certainly of any other form of progress or even change; it simply models particular technologies as linear processes.

Ballonoff has identified an appropriate test for the 'newness' and value of multi-agent modeling. The response in this case is straightforward. Leontief's Input-Output Models (Leontief 1986) are excellent for describing secondary and indirect outputs based on the interactions of processes or technologies, assuming that one has been able to fit the data into an appropriate matrix of relationships between the technologies concerned. The process of producing this matrix from a data set serves as both a platform for evaluating theories that indicate relationships between technologies and analytically determining these relationships from the data set being analyzed.

However, as Ballonoff indicates, Leontief's model "ignores the dynamics of possibly changed preferences and the possibility of 'technological progress' and certainly of any

other form of progress or even change; it simply models particular technologies as linear processes." While this may be true of Leontief's technological coefficients, it is not true of multi-agent modeling. Key aspects of multi-agent modeling are representing differentiation between agents in preferences, for example, incorporating a mix of 'agents of change' together with more conservative and stable agents (Bharwani 2006), the introduction of external change or 'progress' that impacts agents differentially and the incorporation of non-linear and non-continuous processes.

Leontief's model is a 'top down' model, appropriate for describing the outcomes of a process, and provides some insight into the internal organization that leads to the outcome. Multi-agent modeling is a 'bottom-up' approach that generally attempts to generate the outcomes as an emergent property of activities and perspectives that may or may not consider larger scale organizations and processes; rather, the larger scale organization and processes emerge from the interactions of rather simpler activities.

The complexity of the outcome stems from the extreme dimensionality represented by a multi-agent model. Potentially each agent will experience a different local perspective, and even with precisely the same algorithm in play for each agent, will produce different local results. However, there is no need for equivalence of algorithms between agents, and indeed in the framework we have described in this paper, where agents learn and adapt individually (influenced by their relationships to other local agents), these algorithms can diverge wildly during the course of the execution of the model.

Indeed we could argue that much of the linearity in a multi-agent model stems from the representation of time in what is inherently a processual form of modeling. The actual agents may, however, not share their experience of that time and in local adaptation will diverge more and more over time.

So Leontief's model may be a good overall description of the data set we are attempting to model, and thus a test of the effectiveness of the multi-agent model in producing a statistically equivalent outcome, but it is not a model of the same sort or kind. That is, it can serve as a good reference model to evaluate a multi-agent model but does not lead to the same kinds of explanations.

Therefore, while we may agree that a multi-agent model is simply a description, it is a description that permits us to evaluate theories far more complex than we can evaluate within the limits of top-down linear models, and thus to increase our ability to explain the outcomes we identify in a given data set. Multi-agent modeling, by opening up the possibilities for testing theory, is very much a theory-building tool. Multi-agent modeling allows us to explore what kinds of agent properties and interactions and what constraints, under what conditions, can produce emergent systems.

There are two basic arguments that can be used to justify relating human cultural processes to a multi-agent modeling framework. The weaker argument is that most anthropological models are of activities embedded in cultural processes, be these using kin, building houses, finding food, controlling traffic, understanding language, regulating nuclear reactors or operating a factory. If the cultural processes are complex, then any model must take that complexity into account in some way. One potentially powerful way is to identify the principal cul-

tural systems and their organization, and to incorporate these into models. I argue that this is implicitly what is done in any case.

Circumstantial adaptations are more often in need of revision as the kinds of circumstances that can arise and often change in contrast to underlying principles, which may not change at all during the period of adaptation. Instantiating knowledge is necessary to produce results from the former two, and thus must be kept dynamically in 'tune' with contemporary circumstances. This is perhaps well illustrated when we attempt to transfer new knowledge. Without incorporation of instantiating knowledge, we are in fact not importing useful knowledge at all because the powerful things that the knowledge enacts in its original context are not present without instantiating knowledge.

A stronger argument takes this point further. I suggest that multi-agent modeling as a method operates under similar constraints to those of human groups. If we are developing a model for which an accepted mathematical model exists, then we are perhaps free of this constraint. Multi-agent models are used in situations where we perceive complexity and a need for non-linear, non-sequential response in order to produce the application desired. This is precisely the area where our usual ways of expressing relationships and processes fail. Conventional propositional calculus and mathematics can only approximate results in these cases, often in a highly fragile form. Multi-agent models are not directed by a single logical system but by many such systems interacting with each other. In some cases these different systems are logically independent in the sense that each system interacts with the overall application process in ways that do not directly impact each other. However, in most real-world cases these different systems are not independent, and the interaction between systems usually requires considerable tuning and even 'hacking' to produce the desired behavior in the application, and this often limits the possible uses of the application.

The cultural-based architecture I have described is a working example of how human groups deal with the problem of adaptively 'tuning and hacking' in maintaining a group or organization over time. By separating the logic of ideation from the logic of instantiation we make explicit the adjustments necessary to produce a consistent solution. The logic of instantiation represents the part of the application that corresponds to the 'real-world' task at hand, producing satisfactory results in different contexts. The logics of the different ideational systems correspond to the data structures combined with the relationships between the data items and the constraints on their use. Formally separating the two produces a system that is far easier to debug, develop and maintain.

For each type of agent we should have two different systems, one that formally defines the ideational components and another that formally defines the instantiation of the former. Deontic logic is ideal for describing multiple ideational components because it defines potential non-monotonic relationships and interactions between these without requiring probabilistic parameters. Imperative logic is well suited for describing procedures for instantiation. Deontic modality defined over an imperative logic explicitly facilitates integrating ideational frameworks with instantiation frameworks, keeping the two apart but permitting one to act on the other. Although a story may be 'science', its instantiation often is not (as yet). In this way we can separate the story from the instantiation.

References

Anderson, E. N., *Ecologies of the Heart: Emotion, Belief, and the Environment.* New York: OUP. 1996.

Ballonoff, Paul, Personal Communication. ND.

Chit Hlaing, F. K. L., On the 'Globality Hypothesis' About Social=Cultural Structure: An Algebraic Solution. *Cybernetics and Systems.* 2005; 36(8).

Chomsky, Noam, *Syntactic Structures*. The Hague: Mouton. 1957.

Christiansen, John H., Mark R. Altaweel, Understanding Ancient Societies: A New Approach Using Agent-Based Holistic Modeling, *Structure and Dynamics: eJournal of Anthropological and Related Sciences*. 2006; 1(2): Article 7.
http://repositories.cdlib.org/imbs/socdyn/sdeas/vol1/iss2/art7/

Coult, Allan D., Richard R. Randolph, Computer Methods for Analyzing Genealogical Space. *American Anthropologist.* 1965*;* 67:21-9.

D'Andrade, Roy G., *The Development of Cognitive Anthropology*. Cambridge: Cambridge University Press. 1995.

Fischer, M. D., *Applications in computing for social anthropologists*. London: Routledge. 1994.

— Integrating anthropological approaches to the study of culture: The 'Hard' and the 'Soft'. *Cybernetics and Systems*. 2004; 35(2/3):147-162.

— Culture and Indigenous Knowledge Systems: Emergent Order and the Internal Regulation of Shared Symbolic Systems. *Cybernetics and Systems*. 2005; 36:8.

— Cultural Agents: A Community of Minds. *Engineering Societies in the Agents World VI*. Oguz Dikenelli, Marie-Pierre Gleizes and Alessandro Ricci (eds). *Lecture Notes in Computer Science*. 2006a; 3963:259-274. (Springer-Vela).

— The ideation and instantiation of arranging marriage within an urban community in Pakistan, 1982–2000. *Contemporary South Asia.* 2006b*;* 15(3):325-339.

Fischer. M. and A. Finkelstein, A case study in social knowledge representation: arranging a marriage in urban Pakistan, in *Qualitative Knowledge and Computing*, eds. N Fielding and R. Lee. London: Sage. 1991.

Fischer, M.D. & D. Read, Final report to the ESRC on Ideational and Material Models. Canterbury: CSAC. 2001.

Fischer, M. D. & S. M. Lyon, George Peter Murdock, In V. Amit (ed.) *Biographical Dictionary of Social and Cultural Anthropology*. London: Routledge. 2004; 367-369.

Fischer, M.D., S. M. Lyon & D. Read, Introduction to Special Issue on Cultural Systems. *Cybernetics and Systems.* 2005; 36(8).

Gilbert, John P. and E. A. Hammel, Computer Simulation and Analysis of Problems in Kinship and Social Structure, *American Anthropologist*. 1966; 68(1):71-93

Hutchins, E., *Cognition in the wild*. Cambridge, MA: MIT Press. 1996.

Kunstadter, P., R. Buhler, F. Stephen, C. F. Westoff, Demographic Variability and Preferential Marriage Patterns. *American Journal of Physical Anthropology*. 1963; 21:511-519

Kuznar, L.. High Fidelity Computational Social Science in Anthropology: Prospects for Developing a Comparative Framework. *Social Science Computer Review*. 2006; 24(1).

Leaf, Murray, The Punjabi Kinship Terminology as a Semantic System. *American Anthropologist*. 1971; 73:545-554.

— *Information and Behavior in a Sikh Village*. Berkeley and Los Angeles: University of California Press. 1972.

— The Message Is The Medium: Language, Culture, And Informatics. *Cybernetics and Systems*. 2005; 36(8).

Leontief, W., *Input-Output Economics*, Second Edition. Oxford University Press. 1986.

Lewis, David, *The voyaging stars Secrets of the Pacific island navigators*. New York: W. W. Norton. 1978.

Lyon, Stephen, Culture And Information: An Anthropological Examination Of Communication In Cultural Domains In Pakistan. *Cybernetics and Systems*. 2005; 36(8).

McGrew, W.C., Evolution of the cultural mind: Lessons from wild chimpanzees. In: *The Social Brain: Evolution and Pathology*, Brüne, M., Ribbert, H. & Schiefenhövel, W. (eds.) New York: Wiley. 2003; 81-92.

McNamara, Paul, Deontic Logic, *The Stanford Encyclopedia of Philosophy* (Fall 2008 Edition), Edward N. Zalta (ed.). 2008.
http://plato.stanford.edu/archives/fall2008/entries/logic-deontic. accessed 9-20-2008.

Maibaum, T. S. E., *A Logic for the Formal Requirements specification of Real-Time/Embedded Systems*. Alley FOREST Deliverable Report 3. Chelmsford: GEC Research Laboratories. 1986.

Montague, R., *Formal Philosophy: Selected Papers of Richard Montague*, edited by Richmond Thomason, New Haven and London: Yale University Press. 1974.

Murdock, George Peter, The Science of Culture. *American Anthropologist*. 1932; 34(2):200-215.

— Anthropology's Mythology. *Proceedings of the Royal Anthropological Institute of Great Britain and Ireland*. 1971; 17-24.

Randolph, R. R., A D Coult, A Computer Analysis of Bedouin Marriage. *Southwestern Journal of Anthropology*. 1968; 24:83-99.

Read, Dwight, Cultural Construct + Instantiation = Constructed Reality. *Human Complex Systems*. Paper DWR2002. 2002. http://repositories.cdlib.org/hcs/DWR2002 accessed 7/10/2008.

— Some Observations on Resilience and Robustness in Human Systems. *Cybernetics and Systems*. 2005; 36(8):773-802.
http://www.informaworld.com/smpp/content~content=a727124854~db=all~order=page

— Kinship Algebra Expert System (KAES): A Software Implementation of a Cultural Theory. *Social Science Computer Review*. 2006; 24(1).

Read, Dwight & Michael Fischer, *Kinship Algebra Expert System*. Canterbury: Centre for Social Anthropology and Computing. 2004. http://kaes.anthrosciences.net accessed 2/1/2008.

Shannon, C. E. & W. Weaver, *The Mathematical Theory of Communication.* First published 1949. Urbana: University of Illinois Press. 1963.

Wallace, Anthony F. C., Culture and cognition. *Science.* 1962; 135: 351-7.

Wallace, Anthony F. C. and John Atkins, The Meaning of Kinship Terms. *American Anthropologist.* 1960; 62(1):58-80.