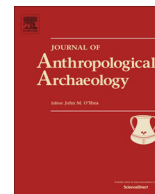




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Are we missing the “sweet spot” between optimality theory and niche construction theory in archaeology?

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ABSTRACT

Proximate decision models, such as those derived from optimal foraging theory (OFT), are important tools for predicting individual behavior and identifying contradictions to our assumptions. The models are effective for exposing anomalies because they play upon basic resource needs and costs in situations where human behavior cannot be observed directly. These decision models are not enough, however, to account for the larger processes by which repeated interactions change the nature of co-evolving species, including humans, and alterations of the conditions of selection across generations. At least two levels of mechanics and their respective temporal domains must be recognized in co-evolutionary studies. These are the primary mechanics of day-to-day decisions and actions, and the compounding mechanics of emergent phenomena that may affect the evolutionary history of populations. Local rules and goals generally govern decisions of individuals or small groups of individuals as they try to balance competing needs. Compounding rules govern emergence of larger phenomena which unfold unpredictably for generations to come. Contra some recent claims, one family of theory cannot replace the function of the other; rather they are complimentary, by speaking to very different scales of phenomena. We develop these points through a consideration of both primary and compounding dynamics in two distinct evolutionary forums: the developmental evolution of the hearth-centered residential camp in the Middle Pleistocene and the “domestic-selective” environment of a formative village at the beginning of the Holocene.

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1. Introduction

Optimal foraging theory (OFT) and related concepts from behavioral ecology are by now well established in anthropology, thanks in large part to the work of Jim O’Connell, his colleagues and students. The best OFT studies are those that expose behavioral anomalies, departures from the predictions of a well-parsed model (e.g., Barlow and Metcalfe, 1996; Bright et al., 2002; Broughton, 1994; Buonasera, 2015; Gremillion et al., 2014; Hawkes et al., 1982; Kuhn, 1994; Lupo, 2007; O’Connell et al., 1988; Stiner, 2001; Ugan et al., 2003; Winterhalder and Smith, 2000). It is the very simplicity of narrowly framed, rigorous models that allows anthropologists to winnow-out false assumptions and to identify the dominant currencies and organizational features of human behavior within and across cultures.

Generative evolutionary theories, including Co-evolution Theory and Evolutionary Developmental Theory (EvoDevo),¹ are well established in the biological sciences. They have a much more limited history of application in anthropology. Evolutionary Developmental Theory is gaining traction recently due to anthropologists’ growing motivation to address complex problems such as dynamic networks and webs of social interaction. Of the many variants of EvoDevo, the concept of Niche Construction (Odling-Smee et al., 2003) is the one most widely discussed by archaeologists (e.g., Smith, 2011; O’Brien and Laland, 2012). One may wonder why archaeologists were not quicker to take up niche construction

¹ For our purposes, co-evolution and developmental theories fall under the same general rubric, simply because they deal with generative phenomena (physical and/or behavioral) that arise from interaction and create selective conditions that are heritable. We introduce them as separate terms initially in recognition of differences that are important to specific applications. What the two areas of theory share in common is a potential for “plastic” modulation of form or behavior as the result of repeated reciprocal or feedback across generations. That the interactions may be among living organisms or between organisms and a mutable environment are important but secondary distinctions.

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theory (NCT), as it seems exceptionally well suited to holistic studies of human beings and their environment. In particular, NCT places a strong emphasis on a dynamic heritable environment (similar to ecosystem engineering, Jones et al., 1997), and humans create artificial environments around themselves as a rule. One obstacle may be the difficulty of really testing NCT in modern contexts (see Odling-Smee et al., 2013; Matthews et al., 2014), much more so in archaeological and paleontological studies of past processes. Another important stumbling block that has surfaced in recent literature, and the one we will address in this paper, is the belief that the different sorts of theory named above exist on single plane of utility and are thus in conflict at the ontological level (Smith, 2011; Zeder, 2012). We argue that this is not the case, and that it is high time to consider the conceptual and operational relations between OFT and NCT in particular (see also Bliege Bird, 2015; Gremillion et al., 2014).

Some background to EvoDevo is important to the argument we present here. Laubichler and Maienschein (2007) trace Evo-Devo thinking to 19th century notions of “generative” process in evolutionary biology. Rooted in early ideas of organismic development, the theoretical potential of generative process was pursued mainly within the confines of embryology, the study of the developing individual (Laubichler and Maienschein, 2007). The generative paradigm has been overshadowed in most other areas of life science by the great successes of classic (Darwinian) evolutionary theory. Today, *generative* refers to how interactions among a set of finite rules yield unanticipated behaviors or other surprising outcomes. It is difficult or impossible to predict such outcomes using simple human brain-power, but computer simulation modeling shows that they can be a consequence of simple rules (e.g., Andersson et al., 2014; Barton et al., in press; Ullah et al., 2015). The unforeseen patterns that emerge can be physiological, social and/or cognitive in nature, and thus would seem to be very relevant to research on human evolution.

An overload of data and nagging gaps in evolutionary explanation have given new urgency to integrating development and evolution in the biological and social sciences. Refinements in co-evolution and EvoDevo theory have been part of this recent trend. The idea of co-evolution from the 1960–1970s (e.g., MacArthur and Levins, 1967) focused on how the interactions among living organisms may disproportionately shape and constrain the evolutionary pathways of one or both taxa by altering the conditions of selection. Niche construction differs from classic co-evolution theory in that it focuses on co-evolution of the organism and its environment, which may also alter the conditions of selection over the long run (Odling-Smee et al., 2003; Laland et al., 2000).

Interaction and “inter-activeness” are central conditions to all EvoDevo and Co-evolutionary theories. Whether the linkages arise from random historical processes or structural basins of attraction, it is the dynamic of interaction that moves the evolutionary processes along. The interactions may be intense or diffuse, but there must be repeated cycles of action and reaction (feedback influences) to produce an evolutive effect.

Much of what we shall consider in this essay concerns the necessary relationships between two distinct levels of theory for archaeology—optimality-based decision models and niche construction, a type of evolutionary developmental theory. First we will lay out what we see as some key logical relations between optimal foraging theory (OFT) and niche construction theory (NCT). We will then illustrate our argument using two archaeological examples of very different ages: (a) the emergence of hearth-focused residential camps during the Middle Pleistocene in Eurasia; and, (b) the birth of the village among early sedentary foragers in Central Anatolia at the beginning of the Holocene.

2. Functional hierarchy in theory

To study human evolution in the broad sense is, more often than not, to study co-evolution—the co-evolution of biology and culture, predator and prey, parasite and host, human and domesticated, technology and body. Humans are an exceptionally manipulative species, and their influence on other organisms and the physical environment is everywhere to be seen. Humans are not altogether unique for being manipulative, but they hold an extreme status in natural systems. Aspects of the forager-producer transition, including constructed environments and risk management practices, as well as the links between stock-keeping and zoonotic diseases, are common examples of feedbacks that have promoted co-evolution. The human-constructed environment has become part of the arena of selective influences in our evolution.

The fact that humans get caught up in intense interactive spirals of all sorts begs explanation, yet seems to lie beyond what much current theory can accommodate. We have seen that close interactions between humans and animals, or between humans and plants, can push the evolutionary process in unprecedented directions, often quite rapidly. But how does it work? And how do immediate constraints and day-to-day behaviors participate in locking people into reciprocal evolutionary pathways with other species and things?

Co-evolution models vary in the specific mechanics of change. Some early ones viewed the process as largely independent of the physical environment such as Van Valen's (1973) Red Queen hypothesis. The tendency to interact brings on selective behavioral constraints that span generations, such as in the case of competition (e.g., Schoener, 1974, 1983). Other, more recent models emphasize how biotic interactions cumulatively alter the selective physical environment for future generations, a proposition that is essential to keystone species effects and niche construction alike (compare Jones et al., 1997; Brown and Heske, 1990; Laland et al., 2000). By modifying the sources of selection in the heritable environment, highly “interactive” species are said to co-direct their evolution mainly through positive feedback loops. The pros of their actions must generally outweigh the cons (though the cons can be significant), and the organisms must be flexible enough to keep adjusting to the changes wrought by the interactions. The modifying activities must persist over multiple generations in order to have a directional effect in evolution, either through Darwinian natural selection (Laland et al., 2000) or some neutral processes (e.g., Lansing and Cox, 2011).

The ‘co-evolvants’ experience directional selection not simply because they are locked in an intense relationship but also because their interactions alter the conditions of life for their descendants. While the term ‘environment’ often implies physical surroundings, social and inter-specific interaction can also be important parts of the selective environment. Importantly, repeated feedback will provoke a host of new challenges that must also be solved in some way (Tainter, 1988). The spiraling nature of feedback relations may eventually lock the species into new states of existence, making it very difficult to retreat to earlier states (Andersson et al., 2014).

The big picture emerges from small dynamics. Herein lies the key to integrating the different levels of theory, such as between OFT and NCT. There is the matter of short-term intentional or goal-directed decisions, and there is the matter of the structures that emerge and ultimately envelop the selection process. The short-term goals and constraints that motivate people are of fundamental importance to archaeology. These models play upon basic resource needs and costs that humans cannot ignore while balancing the checkbook of life. Because archaeologists cannot observe prehistoric behaviors directly, assumptions about basic

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