

27th ALTENBERG WORKSHOP IN THEORETICAL BIOLOGY

Cultural Niche Construction

organized by

Kevin Laland and Mike O'Brien

September 22 - 25, 2011

Konrad Lorenz Institute

for Evolution and Cognition Research

Altenberg, Austria

The topic

Niche construction theory (NCT) is a relatively new development within evolutionary biology, but one that has important implications for many adjacent fields of research, including the human sciences. NCT places emphasis on the capacity of organisms to modify natural selection in their environment and thereby act as co-directors of their own, and other species' evolution. Examples of niche construction include animals manufacturing nests, burrows, webs, and pupal cases; plants changing levels of atmospheric gases and modifying nutrient cycles; fungi decomposing organic matter; and bacteria fixing nutrients. Organisms also construct and destroy resources and habitat utilized by other species in their environments ('ecosystem engineering'). These interactions connect diverse organisms and create 'engineering control webs' and 'eco-evolutionary feedbacks' that potentially greatly affect the stability of ecosystems.

While niche construction is a general process, human niche construction may be uniquely potent among that of all species. In the last 100,000 years, humans have dispersed from East Africa around the globe and exhibited massive population growth. This success story would have been impossible without their ability to modify environments to compensate for different climatic regimes and other challenges—manufacturing clothes and shelters, controlling fire, devising agricultural practices, and domesticating livestock. Recent genetic analyses strongly suggest that human cultural activities have triggered selective sweeps of alleles newly favored in these constructed environments, thereby substantially shaping the human genome. Humans have become adapted to a cultural niche. At the same time, human cultural activities have created new niches for other species, such as domesticates and commensals, whilst destroying countless others by eroding engineering control webs.

The basis for human success as a species is the inordinately high capacity for learning that its members possess. The significance of acquired characters to evolutionary processes becomes amplified with transgenerational culture, creating what anthropologists refer to as "traditions"—patterned ways of doing things that exist in

identifiable form over extended periods of time. When humans engage in niche construction, they thereby modify the learning environments for themselves and others in their population, scaffolding innovation and channeling development along particular pathways. Through their activities humans construct not only an ecological niche but also a developmental niche, an aspect of NCT that remains under-explored.

As of yet, the developing interest in human niche construction may seem akin to a ripple within the human sciences as a whole, but there is growing evidence of a multidisciplinary initiative that includes fields such as philosophy, primatology, psychology, evolutionary anthropology, and demography. In any one discipline, the impact of NCT may still yet be modest, but across them collectively, it is starting to become a powerful movement.

Aims

We expect the Altenberg Workshop in Cultural Niche Construction to make progress on fundamental issues in NCT that have considerable bearing on the human sciences. We will set out to clarify the role of human cultural activities in shaping ecological and developmental niches, sharpening the conceptual tools that NCT brings to these disciplines, and seeking to devise a conceptual framework that will be of widespread utility. To that end, we have invited evolutionary biologists, anthropologists, philosophers, psychologists, ecologists, and human geneticists to present papers, participate in the discussions, and contribute to a publication.

Cultural Niche Construction

Thursday
22 September

Evening

6.00 pm

Welcome reception and dinner at the KLI

Friday
23 September

Morning

Evolutionary and Ecological
Foundations

Chair:
Laland

9.00 am – 9.45 am

Laland &
O'Brien

Introduction and Overview

9.45 am – 10.40 am

Palkovacs

Eco-Evolutionary Feedbacks in a Human-Dominated
World

10.40 am – 11.10 am

Coffee

11.10 am – 12.05 am

Cuddington

Modeling the Population Consequences of
Ecosystem Engineering

12.05 am – 1:00 pm

Sean Myles

The Past and the Future of Human-mediated
Genetic Change

1:00 pm – 2.30 pm

Lunch

at the KLI

Friday 23 September	Afternoon	Human Biology	Chair: Laland
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2.30 pm – 3.25 pm	Hurtado & Hill	Ground Truthing Three Pillars of Human Uniqueness: Collective Action, Public Health, and Longevity
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3.25 pm – 4.20 pm	Flack	Social Niche Construction through Collective Computation
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4.20 pm – 4:50 pm	Coffee
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4.50 pm – 5.45 pm	Odling-Smee	Reflections on the earlier talks
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6.00 pm	Departure for Dinner
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Saturday 24 September	Morning	Comparative, Developmental, and Theoretical Perspectives	Chair: O'Brien
9.00 am – 9.55 am	Gray	Tool Manufacture, Niche Construction, and the Evolutionary Role of Template Matching	
9.55 am – 10.50 am	Fragaszy	Using NCT to Understand How Nonhuman Primates Maintain Technical Traditions and to Predict Their Distribution	
10.50 am – 11.20 am	Coffee		
11.20 am – 12:15 pm	Kendal	NCT in the Social Sciences: The Role of the Constructed Learning Environment	
12.15 am – 1:00 pm	O'Brien & Laland	NCT and the Human Sciences: Developing A Practical Theoretical Framework	
1.00 pm - 2.30 pm	Lunch	at the KLI	
Saturday 24 September	Afternoon	Case Studies in Human Niche Construction	Chair: O'Brien
2.30 pm –3.25 pm	Smith	A Resource-catchment-scale General Model of the Role of Niche Construction in Agricultural Origins	
3.25 pm –4.20 pm	Collard, Buchanan, Ruttle, & O'Brien	Niche Construction, Risk, and Technology in Small-scale Societies	
4.20 pm – 4:50 pm	Coffee		
4:50 pm – 5:45 pm	Kovacevic, Shennan, & Thomas	Modeling the Spread of Aurignacian Material Culture: Were the First Modern Humans in Europe Ethnolinguistically Structured?	
6.00 pm		Departure for Dinner	

Sunday 25
September

Morning

Discussion

Chair:
Leland

9.00 am – 9.55 am

Feldman

Cultural Niche Construction: Some Principles and
Examples from Son Preference

9.55 am – 10.50 am

Keller

Reflections on the earlier talks

10.50 am – 11.20 am

Coffee

11.20 am – 1.00 pm

General
Discussion

Key Issues to Emerge, Points of Contention,
Problems and Solutions, etc.

1.00 pm – 2.10 pm

Lunch

at the KLI

Abstracts

Kevin N. LALAND

University of St Andrews

Michael J. O'BRIEN

University of Missouri

Introduction

Niche construction is the process whereby organisms, through their activities and choices, modify their own and each other's niches. By transforming natural selection pressures, niche construction generates feedback in evolution, on a scale hitherto underestimated and in a manner that alters the evolutionary dynamic. Niche-constructing species also play important ecological roles, by creating habitat and resources used by other species and thereby affecting the flow of energy and matter through ecosystems ("ecosystem engineering"). An important insight from NCT is that acquired characters play an evolutionary role, through transforming selective environments. This is particularly relevant to human evolution, where our species appears to have engaged in extensive environmental modification through cultural practices. Such practices are typically not themselves biological adaptations and, hence, cannot accurately be described as "extended phenotypes." Mathematical models (1) reveal that niche construction resulting from human cultural processes can be even more potent than gene-based niche construction and (2) establish that cultural niche construction can modify selection on human genes and drive evolutionary and co-evolutionary events. Humans can also construct developmental environments that feed back to affect how individuals learn and develop, and the diseases to which they are exposed. We will set the scene for the workshop by giving an introduction to NCT and illustrating some of its more important implications for the human sciences.

Eric PALKOVACS

Duke University

Eco-evolutionary Feedbacks in a Human-Dominated World

Recent research shows that ongoing evolution can have important implications for ecosystems, which can then feed back to impact the trajectory of evolution. Most eco-evolutionary studies to date have examined such processes at relatively small spatial and temporal scales, often in laboratory systems. However, an eco-evolutionary framework can be extended to explain longer-term and larger-scale ecological and evolutionary processes. Human activity is now a principal driver of both ecological and evolutionary change worldwide. Thus, predicting the future of Earth's ecosystems may depend critically on understanding how eco-evolutionary feedbacks operate under current and future conditions of anthropogenic forcing.

Kim CUDDINGTON
University of Waterloo

Modeling the Population Consequences of Ecosystem Engineering

With few exceptions, the feedback between the abiotic environment and living organisms has been neglected in the development of theories of population and community ecology. In the mid-1990s the concept of 'ecosystem engineers', species which have known effects on the abiotic environment, was introduced to draw attention to this knowledge gap. While ecologists began to use this concept to organize empirical studies, the development of corresponding general mathematical theory lagged behind. Using quite simple and very general models of biotic-abiotic feedback, I demonstrate that a consideration of such relationships changes theoretical predictions regarding population dynamics, invasive species, and predator-prey interactions.

Sean MYLES

Cornell University

The Past and the Future of Human-mediated Genetic Change

Our recently acquired ability to collect and analyse large amounts of DNA sequence data has provided critical insights into how natural selection operates at the molecular level. Studies of human genetic variation have uncovered numerous genes affected by positive natural selection. There is strong evidence that much of this selection derives from culture, and I show that NCT can be used to test hypotheses concerning the origins of adaptive human phenotypes. In addition to shaping our own genomes, humans have clearly had an enormous influence on other organisms. Focussing on insights from agricultural genomics, I demonstrate how and to what extent humans have shaped the genomes of diverse organisms. Finally, I argue that NCT provides an important framework to understand not only the past, but also the future impacts humans are likely to have on patterns and levels of global genetic diversity.

Magdalena HURTADO & Kim HILL

Arizona State University

**Ground Truthing Three Pillars of Human Uniqueness:
Collective Action, Public Health, and Longevity**

This talk will focus on empirical aspects of the social transmission and inheritance of public health knowledge and public health material culture in small-scale Kuna communities of Panama. The presentation uses photos, videos, and interviews to illustrate the complex web of short-term and long-term transmission of information or rules designed to solve public health-related collective action problems among the Kuna. The presentation will conclude with a list of problems concerning the ancestral role of public health niche construction and the emergence of unique aspects of our life history.

Jessica FLACK
Santa Fe Institute

Social Niche Construction through Collective Computation

We propose that aggregate spatial and temporal patterns, represented as coarse-grained variables, arise through an optimization process in which individuals compete for local rewards, leading them to adopt strategies that are either transiently or long-term stable. When these strategies, or decision-making rules, can be extracted from time-series data, they can be used to construct adaptive social circuits. Social circuits provide a compact description of the collective effects of rule implementation and causally relate rules at the individual level to the statistical properties of aggregates. This defines a simple form of social computation and provides a mechanistic explanation for social niche construction.

Russell GRAY

University of Oackland

Tool Manufacture, Niche Construction, and the Evolutionary Role of Template Matching

In this talk I will draw on our recent work on the development of pandanus tool manufacture in New Caledonia crows to outline the general role that template matching might play in cultural evolution. I will argue that template matching provides an alternative mechanism to imitation for high-fidelity social transmission. I will speculate on the evolutionary role template matching may have had in hominin tool manufacture and the evolution of language.

Dorothy FRAGASZY
University of Georgia

Using Niche Construction Theory to Understand how Nonhuman Primates Maintain Technical Traditions and to Predict their Distribution

All primates develop and learn in a rich social setting (a social niche). Some species of nonhuman primates display technical traditions, such as using tools in foraging, in the absence of direct teaching or language. Using capuchin monkeys as an illustrative case, I describe how social partners influence young monkeys' technical skill development across temporal scales, and how enduring physical alterations are part of the socially constructed environment in which they learn these skills. Expanding the concept of social niche to incorporate physical alterations deepens its reach, and aligns it with another body of theory guiding human developmental research—Vygotskian theory. Perhaps by specifying the “social niche” characteristics of social groups and foraging activities supporting known technical traditions, we can model the temporally and geographically uneven appearance of technical traditions in extant nonhuman primates, and by extension, the uneven presence of specific technical traditions in ancestral humans.

Jeremy KENDAL
Durham University

Niche Construction Theory in the Social Sciences: The Role of the Constructed Learning Environment

Using evolutionary theory to explore human behavior and culture is still widely rejected by social scientists. However, it appears that NCT may be useful to address some important concerns and theories in cultural and ecological psychology as well as cultural and social anthropology. The idea that learning is affected by the culturally and historically structured environment is highly relevant to activity theory, the process of legitimate peripheral participation, and Vygotsky's zone of proximal development. NCT may also be germane to the notions of habitus, structuration, distributed cognition, and actor-network theory. The relevance of NCT in the above will be explored with particular reference to apprenticeship and ritual. The challenge is in translating apparent compatibility between social science theories and NCT into a practical program of empirical science.

Michael J. O'BRIEN
University of Missouri

Kevin LALAND
University of St Andrews

Niche Construction Theory and the Human Sciences: Developing a Practical Theoretical Framework

Theory and empirical data from a variety of disciplines strongly imply that recent human history involves extensive gene–culture co-evolution, much of it as a direct result of human agricultural practices. Here we draw on NCT and gene–culture co-evolutionary theory (GCT) to propose a broad theoretical framework (NCT–GCT) with which archaeologists and anthropologists can explore co-evolutionary dynamics. Humans are enormously potent niche constructors, and understanding how niche construction regulates ecosystem dynamics is central to understanding the impact of human populations on their ecological and developmental environments. We use as primary examples the evolution of dairying by Neolithic groups in Europe and Africa and the rise of the “sickle-cell allele” among certain agricultural groups in West Africa, and suggest that these examples are broadly representative of much of human recent history. Although the core aspects of these case studies are familiar, we lay out the examples with a specific NCT–GCT focus, which allows us to highlight how archaeology, when coupled with genetic research, can play an important role in better understanding human history. Finally, we suggest that the NCT–GCT perspective is likely to be of widespread general utility because it inherently promotes consideration of the active agency of humans, and other organisms, in modifying their ecological and developmental niches, and naturally draws attention to the various forms of feedback that flow from human activities at multiple levels, in multiple populations, and across multiple species.

Bruce D. SMITH
Smithsonian Institution

A Resource-catchment-scale General Model of the Role of Niche Construction in Agricultural Origins

This presentation integrates and expands on two recent considerations of cultural niche construction by small-scale societies (Smith 2007, 2011). A set of general principles of how small-scale societies structure and sustain their energy capture strategies within resource catchment areas is first outlined, drawing on concepts currently employed in wildlife ecology, human behavioral ecology (HBE), and traditional ecological knowledge (TEK) analysis. These general principles in turn are employed in framing, at the scale of individual small-scale societies and their resource catchment zones, a general theoretical model of how niche construction played a central role in the initial domestication of plants and animals world-wide.

Mark COLLARD
Simon Fraser University
University of Missouri

Briggs BUCHANAN
Simon Fraser University
University of Missouri

April RUTTLE
Simon Fraser University

Michael O'BRIEN
University of Missouri

Niche Construction, Risk, and Technology in Small-scale Societies

It is widely accepted in the community of researchers interested in human niche construction that farmers are more active niche constructors than hunter-gatherers (e.g., Laland & O'Brien 2010; Reide 2011; Rendell et al. 2011; Shennan 2011; Smith 2011). One of the predictions of this hypothesis is that farmers should be less directly affected by macroscale environmental variables such as Effective Temperature and Net Above Ground Productivity than hunter-gatherers. Here, we report a study in which we tested this prediction with subsistence toolkit data for 30 hunting and gathering populations and 45 subsistence farming populations. To generate the toolkit data we employed a method developed by the anthropologist Wendall Oswalt in the 1970s (Oswalt 1973, 1976) and subsequently used by a range of authors (e.g., Torrence 1986; Collard et al. 2005; Read 2008). We then combined the toolkit data with data pertaining to a number of macroscale environmental variables. Subsequently, we assessed the strength of the relationships between the three main measures of toolkit structure that have been discussed in the literature and the environmental variables. We began with the hunter-gatherers and then analyzed the farmers. Lastly, we compared the correlation coefficients obtained in the analyses of the hunter-gatherers

with the correlation coefficients obtained in the analyses of the farmers. The results of the analyses were consistent with the prediction that the food-getting technology of farmers should be less strongly correlated with macroscale environmental variables than is the food technology of hunter-gatherers. As expected, we found stronger correlations in the analyses of the hunter-gatherers than in the analyses of the farmers. The implications of this finding are discussed.

Mirna KOVACEVIC
Stephen SHENNAN
Mark G. THOMAS (presenting author)
University College London

**Modeling the Spread of Aurignacian Material Culture:
Were the First Modern Humans in Europe Ethno-linguistically Structured?**

A high degree of structuring is seen in the spatial distribution of symbolic artefact types associated with the Aurignacian culture in Upper Paleolithic Europe, particularly the degree of sharing of ornament forms. Multivariate analyses of these distributions have been interpreted as indicating ethno-linguistic differentiation, although simpler explanations such as isolation-by-distance have not been formally discounted. Ethno-linguistic structuring is a form of cultural niche construction and if present would have important effects on the evolutionary dynamics of human populations. In this study we have developed a spatio-temporally explicit cultural transmission simulation model that generates expectations of a range of spatial statistics describing the distribution of shared ornament types. We compare these simulated descriptive spatial statistics to those observed in the archaeological record for Aurignacian Europe—using Approximate Bayesian Computation—in order to test and compare a range of hypotheses concerning group interaction dynamics for the period. Among the set of hypotheses examined, we include ones where inter-group similarities or differences in material culture do or do not drive inter-group sharing or conflict, respectively.

Marc FELDMAN
Stanford University

**Cultural Niche Construction:
Some Principles and Examples from Son Preference**

Early models assumed that cultural transmission rates, and fitnesses of a dichotomous trait, depended on parental and offspring genotypes.¹ The result was effective selection on genotypes whose pattern and strength depended on the dynamics of the culturally transmitted trait. Extensions of such models do not have to involve genes but may allow variability in one trait to determine the evolutionary forces on another.² I will show some general forms of such models, and how they might be applied to the effect of son preference on marriage customs.

1. Feldman MW, Cavalli-Sforza LL (1976) Cultural and biological evolutionary processes, selection for a trait under complex transmission. *Theor. Pop. Biol.* 9: 239–259.
2. Ihara Y, Feldman MW (2004) Cultural niche construction and the evolution of small family size. *Theor. Pop. Biol.* 65: 101–111.