

Workshop on the evolutionary theory of learning
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Abstracts

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Patterns of cultural change in the Middle and Upper Palaeolithic of the Levant

The rate of cultural changes significantly differed between the Middle and the Upper Palaeolithic periods in Eurasia. The latter saw far more rapid changes in a relatively short period. Given that culture is a product of learned behavior, this phenomenon suggests that the learning processes or even inherited ability of learning might have differed between the Middle and the Upper Palaeolithic hominids. In order to contribute to the understanding of this phenomenon, this paper explores possible differences in the driving forces of the cultural changes between these two periods. As a case study, it investigates the changing patterns of the lithic manufacturing traditions of these two periods in the Levant. More specifically, we first show a chronology and the geographic distributions of lithic industries as well as associated human fossils, followed by a discussion on the causes and meanings of the changes in lithic industries. Finally, we present our current perspective towards the interpretation of these changes in terms of prehistoric learning behaviors.

Ryosuke Kimura

University of the Ryukyus

Reconstruction of the history of human migrations and admixtures from genome data: how to interpret multivariate genomic analyses

The purpose of this research is to obtain the knowledge of human range expansion and migration by using human genome diversity data. To analyze the demographic history and population structure of multiple populations from huge polymorphism data, we often use multivariate analyses such as phylogenetic analysis, principal component analysis, and cluster analysis. However, it has been reported that the statistical results obtained do not always reflect the past migrations and admixtures, but are sometimes produced as distortion due to the mathematical analysis. In this study, several patterns of migrations were computationally simulated, and possible patterns of mathematical artifacts were sorted out. I found patterns specific to certain demographic models, which may be helpful to interpret the results from real data and to reconstruct a model of human expansion based on multivariate analyses. The present study also focuses on migration wave(s) to the Asia-Pacific region.

Laurent Lehmann

University of Lausanne

The handaxe and the microscope: cultural innovations in a geometric model of adaptation

A cultural trait or artifact may consist of many different underlying factors, which jointly determine the utility or fitness benefit of the trait to its carrier. When an innovation arises in the space of factors, what is the probability that it will be beneficial to its carrier and the trait move closer to the optimum? Using Fisher's multidimensional geometric model of evolutionary change, this talk presents probabilities of beneficial innovations and the time dynamics of the distance towards the optimum when innovations can be targeted towards the optimum trait through individual learning. When directional learning towards the optimum occurs in all dimensions, cultural innovations can be beneficial rather than deleterious, but this depends critically on a balance between the dimensionality of the trait (complexity), the individual learning rate, and the distance of the parental trait from the optimum. The stationary distribution of the distance to the optimum may stabilize far away from it unless drastic technological jumps occur. These results may be relevant for interpreting cultural artifact change in the archaeological record.

Stephen Shennan

University College London

Demography, adaptation and cumulative culture

Cumulative culture can refer to an increase in the number of different cultural attributes possessed by an individual or a population, or to the achievement of cultural states that cannot be reached without the prior existence of intermediate states (the cultural ratchet). While there will obviously be some sort of relationship between the two, my talk will focus on the cultural ratchet aspect. Much of the debate about the origin of 'behavioural modernity' has focussed on the appearance of particular cultural attributes as an index of genetically-evolved species capacities, and assessing differences between these is clearly relevant to, for example, comparing modern humans and Neanderthals. But the presence or absence of a particular behaviour in a particular context, and even less evidence of its presence/absence in archaeological residues, cannot be taken as a reliable index of capacities, both because what individuals do depends on the specifics of particular situations and the factors affecting them as well as on their knowledge and capacities, and because specific cultural attributes are properties of populations linked by cultural transmission rather than species. The issues are particularly clear in the case of the appearance and disappearance of some complex technologies in the later African MSA, and in the archaeology of Australia, both cases that involve anatomically modern humans only. Australia is especially interesting because in its c.45 kyr of human occupation it seems to virtually recapitulate developments that took far longer elsewhere and involved ancestral human species. My talk will focus on the issues these cases raise and the role of demography and adaptation in accounting for them.

Kenichi Aoki
University of Tokyo

Innovativeness, population size, and cultural evolution

Beginning with Cavalli-Sforza and Feldman, methods of population genetics have been applied to the study of cultural evolution. The pathways and modes of transmission of cultural traits differ from those of genes, and as a result cultural traits show interesting dynamics not shown by genes. For example, in the case of best-of- k transmission, each newborn imitates the individual with the “highest” skill level among his/her k acquaintances; and with one-to-many teacher transmission, one particular individual (the “teacher”) continues to serve as the exemplar (cultural parent) for many novices.

The Moran model is a stochastic model of random genetic drift in population genetics. Changes in gene frequencies are formulated as a birth-death process, providing an effective and simple means of calculating fixation probabilities and stable distributions. In addition, the Moran model is intrinsically more suitable than discrete generation models for the analysis of cultural phenomena, since the unit of time is shorter than one generation. We define the cultural Moran model by modifying the Moran model and compute the long-term cultural evolutionary rate for various modes of transmission. We also introduce the Moran model version of Henrich’s model, which can be used to show that the effect of larger population size in facilitating cumulative cultural evolution is much greater than in the original model. These findings are useful in interpreting rates of change of lithic traditions.

Joseph Henrich
University of British Columbia

It's Better to be Social than Smart

To better construct models of cultural evolution and gene-culture coevolution, theorists should increasingly leverage what has been learned empirically about culture, including both micro-level transmission processes and macro-level population patterns. This talk reviews and consolidates this growing body of empirical work from laboratory and field studies done in economics, biology, psychology and anthropology. At the micro-level, these findings suggest that humans and other animals use a variety of cues, including success, skill, age, sex, ethnicity, and prestige, to preferentially select individuals to attend to and learn from (their “preferred models”), though learners are sensitive to the costs of access to preferred models. Over the life course, this often simplifies to a two-stage learning process in which young learners first acquire cultural information from within their families and then later update from their preferred models who are drawn from a larger population. For domains of culture with sufficient complexity, this may be the dominant process building cultural adaptations. Consistent with this, at a macro-level, several lines of evidence indicate that the size and interconnectedness of populations are linked to the cultural complexity, and that declines in population size or interconnectedness can result in the loss of cultural know-how, and an inability to re-generate it.

Taken together, this array of evidence suggests that our species' great ecological success is due to the coevolution of our sociality and our species' particular forms of cultural learning.

Wataru Nakahashi

Meiji University

Vertical transmission and updating by horizontal transmission

Changes of lithic industries in modern humans were far more frequent than in Neanderthals. Such rapid cultural changes of modern humans may have started in the Middle Stone Age of Africa. What caused the different cultural evolutionary rates between Neanderthals and modern humans? Previous studies have argued that increased population size and density provoked the high cultural evolutionary rates in modern humans. These studies assumed that learning and cognitive abilities of Neanderthals were the same as those of modern humans. Therefore, why Neanderthals could not learn modern human technologies and went extinct was not explained. In this talk, I assume that Neanderthals and modern humans had different social learning process. Field studies show that modern humans initially learn behaviors by vertical transmission in childhood and update them by horizontal transmission in adolescence and adulthood. If Neanderthals lacked updating process, we can explain why their cultural evolution was slow and why they could not learn modern human technologies and went extinct. I test the hypothesis that the different learning strategies are evolutionary responses to different socio-demographical factors such as population size and group size between the two species.

Yutaka Kobayashi

University of Tokyo

Evolution of social versus individual learning in an infinite island model

I will talk about a mathematical model of the evolution of learning in a population composed of infinitely many, finite-sized islands connected by migration. It is assumed in this model that there are two discrete strategies, social and individual learning, and that the environment is spatially homogeneous but varies temporally in a periodic or stochastic manner. Applying a population-genetic approximation technique to this model yields a mathematical condition for the two strategies to coexist stably and a formula for the equilibrium frequency of social learners under stable coexistence. Analytical and numerical results both reveal that social learners are favored when island size is large or migration rate between islands is high, suggesting that spatial subdivision disfavors social learners. It is also shown that the average fecundity of the population under stable coexistence of the two strategies is in general lower than that in the absence of social learners and is minimized at an intermediate migration rate.

Marcus Feldman (with Michal Arbilly)

Stanford University

Evolution of Learning and Cognition in Producers and Scroungers

Learning is studied in the Producer-Scrounger (P-S) game. First, we study conditions under which a learner that optimizes its behavior can invade a pure or mixed population of non-learning producers and scroungers. Second, we ask whether learning of a complex trait can out-compete learning of a simple trait in a population of producers and scroungers. Finally, we propose a model for evolution of cognition in the P-S game that may be relevant to a number of other competitive situations. All the analyses use agent-based simulations.

Magnus Enquist (with Alberto Acerbi and Stefano Ghirlanda)

Stockholm University

The evolution of fashion cycles

Certain cultural traits exhibit volatile dynamics, commonly dubbed fashions or fads. We will show how realistic fashion-like dynamics can emerge spontaneously if individuals can copy others' preferences for cultural traits as well as the traits themselves. Using simple mathematical models, the diffusion and the subsequent abandonment of a fashion trait is studied in some detail. We also simulate the coevolution between many cultural traits and the associated preferences. This allows us to study also the initial emergence of preferences. These simulations also reproduce power law frequency distributions of cultural traits (most traits are adopted by few individuals for a short time, and very few by many for a long time), as well as correlations between the rate of increase and the rate of decrease of traits (traits that increase rapidly in popularity are also abandoned quickly and vice versa). We also establish that alternative theories, that fashions result from individuals signaling their social status, or from individuals randomly copying each other, do not satisfactorily reproduce these empirical observations.

Joe Yuichiro Wakano

Meiji University

Competition for empty space among individual and social learners

In the replacement of Neanderthals by modern humans, range-expansion might have played an important role. In this study, we model the invasion dynamics by a population consisting of individual and social learners into a new habitat (empty space) and perform the theoretical analysis. Such an explicit model of range-expansion is important to understand the evolution of advanced individual learning ability in modern humans, because modern humans experienced rapid range-expansion during "out-of-Africa." Here we model the spatial population dynamics of individual and social learners by a reaction-diffusion system. One feature of our model is the inclusion of the possibility that social learners may fail to find an exemplar to copy in

regions where the population density is low. Due to this attenuation effect, the invasion speed of social learners is diminished, and various kinds of invasion dynamics are observed although we assume that environment (and thus correct behavior) is spatiotemporally uniform. Our primary findings are: (1) individual learners can persist indefinitely when invading empty space; (2) the occurrence of individual learners at the front may inhibit the spread of social learners. These results suggest that "out-of-Africa" may have driven the evolution of advanced individual learning ability in modern humans.

Kohkichi Kawasaki

Doshisha University

Reaction-diffusion model for range expansion of modern humans in a heterogeneous environment

Abstract not received.