The Role of Culture in Early Expansions of Humans

HEIDELBERG ACADEMY OF SCIENCES AND HUMANITIES

THE ROLE OF CULTURE IN EARLY EXPANSIONS OF HUMANS

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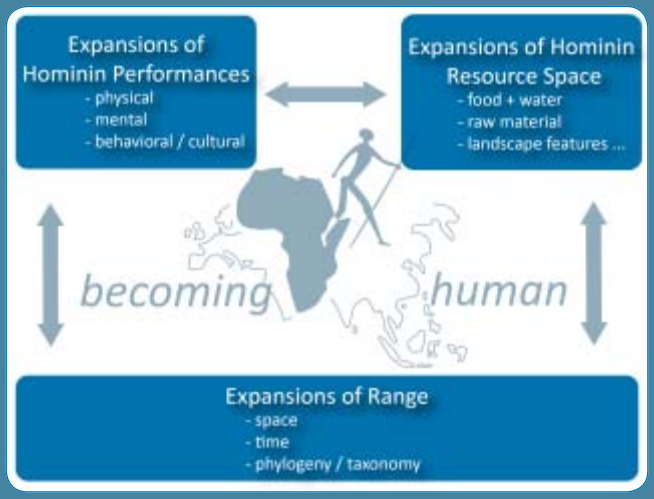

Fig. 1 Expansions scheme highlighting the theme "becoming human".

The Role of Culture in Early Expansions of Humans

During the last two million years, the geographic range of the human species expanded in several waves from its original African homeland to encompass Asia and Europe. Of these hominin species, only anatomically and behaviorally modern humans, *Homo sapiens sapiens*, have been able to overcome all of the impediments imposed by the physical geography of this planet. Within a few tens of thousands of years, modern humans successfully colonized the globe, settling in Australia, the Americas and even the polar regions.

The causes of human range expansions can be attributed to two main factors which interacted over time. Natural factors such as environmental change or physical adaptation influenced human evolution, while cultural factors including technology progressively helped humans overcome the limitations imposed by their physical form. Nevertheless, the development of hominin performances, whether physical, mental or behavioral, whether natural or cultural, cannot be understood in isolation. This is because hominin performances are interdependent with other aspects and capabilities of the human species and its environmental resource space.

The scientific scope of the Research Center "The Role of Culture in Early Expansions of Humans" (ROCEEH) aims to characterize the range expansions of hominins in terms of taxonomy, geography and chronology. Another aim is to understand how range expansions relate to the following factors: expansions of ecospace; the natural environment inhabited by hominins; hominin performances; and above all, human cultural behavior.

Based on the reconstruction of hominin expansions in Africa and Eurasia between three million and 20,000 years ago, ROCEEH seeks to generate a systemic understanding of human evolution which integrates cultural behavior, human biology and environment, and thereby enables the development of an evolutionary concept of the human self.

WAVES OF EXPANSION

After the appearance of the genus *Homo* and the first production of stone tools about 2.5 million years ago, groups of hominins began to leave their continent of origin. Outside of Africa, the earliest traces of humans date to 1.8 million years ago in the Caucasus. By 1.2 million years ago hominins had reached Europe and settled in the regions of East and Southeast Asia. This initial expansion out of Africa marks not only the beginning of many smaller and larger phases of human expansion, but also of ongoing shifts in the distribution range of different populations. Genetic evidence illuminates the complex picture of the last 400,000 years. With expansions from Africa and within Eurasia, several hominin species existed contemporaneously; these populations were separated, replaced and even admixed. In summary, earlier hominins had already expanded into new regions long before modern humans populated the entire globe between 100,000 and 10,000 years ago during the last major expansion event.

Geographical range expansions reflect the potential of hominins to colonize a wider range of environments – expansions of the ecospace – and extend their access to a wider range of resources – expansions of the resource space. The expansion of cultural capacities in hominins broadened the freedom of actions and interactions with the environment. Thus human evolution is not merely a sequence of range expansions triggered by various environmental and cultural factors, but rather a network of interdepending expansions resulting in a multitude of different patterns of range, ecospace, resource space and cultural behavior.

Fig. 2 Mumba Cave is a rockshelter on the shores of Lake Eyasi in Tanzania. The rich collection of artifacts collected from several archaeological horizons document the gradual transition of culture from the Middle to Later Stone Age. (Photo: C. Hertler)

Fig. 3 The maxilla Sangiran 4 is about one million years old and was discovered in Java, Indonesia. The complete specimen additionally includes a brain case which is not connected to the upper jaw. (Photo: A. Stolp))

Fig. 4 Fossil plants such as this maple leaf, *Acer ibericum* (M.Bieb.), tell us about vegetation and climate history and help us understand the environment of early humans, their habitats and potential resources. (Photo: A. Bruch)

Fig. 5 Typical stone tools from the Early Aurignacian of Geißenklösterle Cave. (Photo: M. Malina)

Fig. 6 Survey of potential sites in eastern Georgia. The Southern Caucasus appears to be a frequently important source, hub, and refuge area for early humans since the Early Pleistocene. (Photo: A. Bruch)

EXPANDING HABITAT SELECTION

Earlier hominins were more selective with respect to the environment they inhabited, but *Homo sapiens* managed to occupy all of the ecological niches available to it. In order to describe the specific environments occupied by hominins through time, ROCEEH reconstructs environmental variables such as temperature, precipitation, vegetation and flora, vertebrate and invertebrate fauna, and features of the landscape. These variables describe the ecospaces inhabited by various hominin populations and allow for comparison. For instance, Early Pleistocene hominin populations in Southeast Asia were more selective than later modern humans in the same region. *Homo erectus* populations inhabited a more limited range of environments than *Homo sapiens*, while the ecospaces of both hominin taxa expanded through time. Moreover, robust and quantitative descriptions of hominin ecospaces represent a unique basis for the identification of putative corridors and barriers significant in the dispersals of hominin populations.

In order to understand the selection criteria used by hominins in their choice of environment, we need to study the factors which render a particular environment more attractive than others. Among these factors are easy access to food, a constant supply of resources throughout the year, and reduced pressure from competitors and predators. In some regions including the Caucasus, hominins preferred diversified habitats, even if such habitats were not spatially extensive. Hominins could counter seasonal shifts in resource availability by simply moving to a different environment located a short distance away.

In order to examine such factors we need to address the resource space of hominins. Which resources were essential to them, and which ones did they exploit only occasionally? The spectrum of resources accessible at a certain point in time depends on the cultural skills and performances of a particular hominin. Resource supply depends on the structure of the environment and its respective dynamics, for instance as a result of glacial and interglacial cycles.

The resource spectrum exploited by hominin populations thus depends on the range of resources offered by a certain environment, as well as parameters such as technology, behavior and cultural skill. One of the key tasks in ROCEEH is to develop and explore the potential of concepts such as ecospace and resource space.

Fig. 7 Ivory objects from the Swabian Aurignacian:
a) mammoth figurine from Vogelherd; b-d) ornaments from Hohle Fels;
e) female figurine from Hohle Fels; f) flute from Geißenklösterle.
(Photos: a, f) J. Liptak; b-e) H. Jensen)

THE ROLE OF CULTURAL BEHAVIOR

The evolution of the genus *Homo* can be evinced through physical changes, the development of new mental capacities, and an adaptation strategy that increasingly emphasized the role of cultural behavior. In the physical realm of our ancestors, more efficient means of bipedal locomotion

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developed; their dentition became less specialized, imposing restrictions on the accessible spectrum of dietary resources; and a more generalized hand structure allowed for a precise grip. Brain volume increased, and specific structures in the brain became more differentiated. The life span of individuals lengthened, allowing an extended phase of learning before adolescence. With the ability to focus joint attention on an external object, hominins developed new possibilities of communication, and with this, social relationships intensified. The ability to pass information from one generation to the next increased, as did the significance of the historical-social development of behavior through learning and teaching.

With the production of the first stone implements about 2.5 million years ago, cultural capacities began to exceed the ability of other animals to use and create tools. By using tools to produce other tools, humans succeeded in manufacturing completely new types of implements. Modular recombination of tools in different problem-solution settings became the basis of increasingly complex *composite tools* such as spears with hafted points, *complementary tool sets* like the bow-and-arrow, and *notional tools* that integrated symbolic systems. The diversification and intensification of tool use created new requirements and affordances for physical, mental and behavioral development, a process which became evolutionarily effective and self-enhancing. The specific resource spaces of human populations was increasingly influenced by historical-socially induced developments.

In a systemic evolution of physical, mental and behavioral performances interdependent with the specific environmental resource space, the possibilities of highly flexible adaptations arose unknown in any other species. A significant focal point of the archaeological component of ROCEEH is to track the social and cultural innovations that shed light on the conditions and steps that led to the unfolding of human behavioral plasticity.

DATA COLLECTION

In addition to a detailed review of the existing literature, the project members conduct fieldwork at many localities in Africa and Eurasia to collect additional datasets. To expand the pool of data we examine Stone Age artifacts recovered from excavations and contained in collections, study faunal remains, analyze pollen, and decipher paleo-landscape features including paleo-lake margins, river terraces, caves, paleosols, erosional and depositional structures and neo-tectonic features.

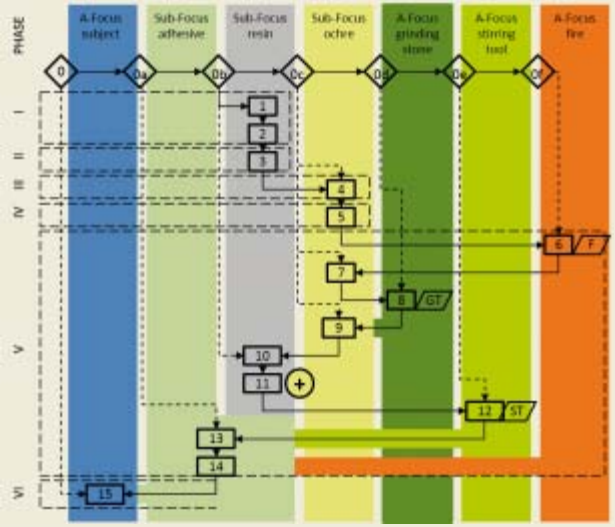

Fig. 8 Cognigram showing the complexity of producing compound adhesive. The main problem-solution process depicts the different foci (colored columns), their effects on each other (horizontal colored bars), and the sequence of actions (rectangles connected by arrows). By comparing cognigrams we can assess technical innovations and changes in the behavioral patterns of early humans.

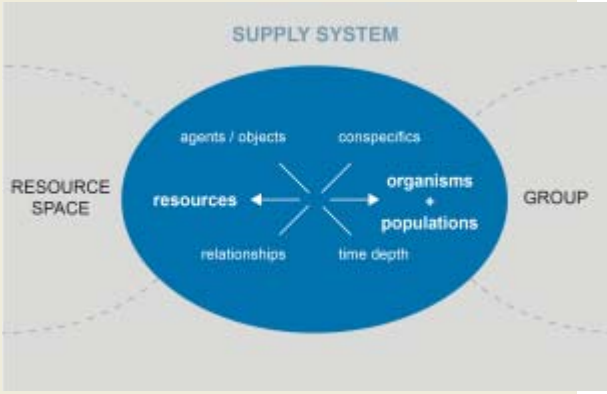

Fig. 9 Supply systems mediate between resources and their users. Supply systems of hominins include categories such as food and water, tool production, as well as other cultural and natural components.

Fig. 10 Excavation at the Middle and Upper Paleolithic cave site of Sefunim Cave. (Photo: A. Kandel)

FROM DATABASE TO DIGITAL ATLAS

The web-based georelational ROCEEH Out of Africa Database (ROAD) is the foundation for the scientific investigation of the expansions of hominins. ROAD integrates archaeology, paleoanthropology, paleontology, paleoecology, vegetation history, climatic records, stratigraphical settings, age models, geophysical and geomorphological information and underlying geographical data, such as digital elevation models, topographic and thematic maps, in standardized and homogenized formats. ROAD allows for the assessment of prehistoric habitats, as well as early human expansion dynamics encompassing archaeological and paleoanthropological perspectives. A web-based georelational database is a prerequisite that enables the various disciplines to access and query all data and visualize them in a geographical framework. ROAD represents the primary means of collecting information within the framework of the project by allowing the controlled exchange of information among project partners, offering public access to selected parts of ROAD, and permitting a sophisticated graphical representation of the research results.

The interdisciplinary datasets are analyzed using a Geographical Information System (GIS) and spatial statistics to understand the spatial and temporal changes and their interdependency. The final results of the role of natural and cultural changes in early human expansions will be presented in a digital atlas of human and environmental history. A special concern of ROCEEH is to make its results accessible to the public.

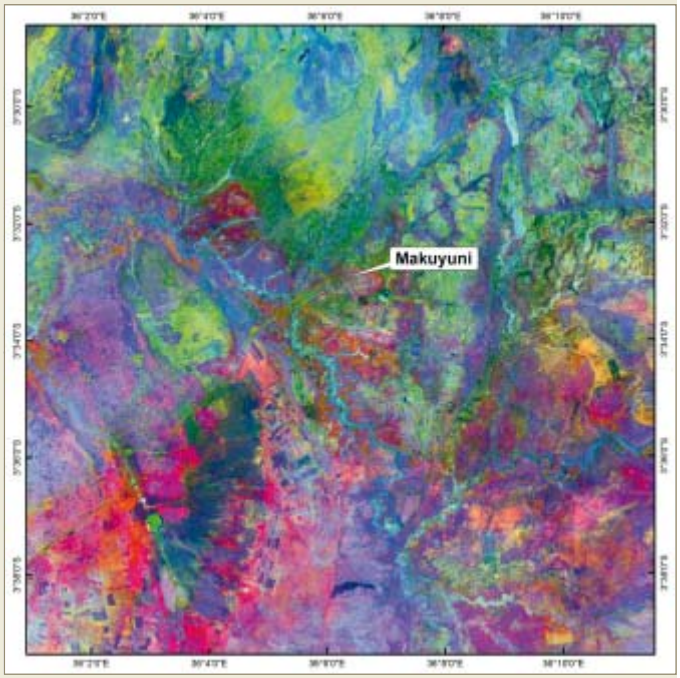

Fig. 11 The principal components (3/2/1) of the ASTER multispectral VNIR and SWIR sensors (23.08.2006) covering the Monduli district, northern Tanzania. The different colors represent homogeneous surface properties with regard to mineral composition and vegetation characteristics: light blue indicates vital vegetation; light greenish colors highlight dry vegetation; reddish colors show high carbonate content; and blueish colors represent dark soils. The Makuyuni River, seen in light blue because of vital vegetation in its river bed, drains into Lake Manyara to the west (Figure: Bachofer & Märker).

MODELING

The spatiotemporal distribution of hominin species and the artifacts associated with them constitute the empirical basis for hominin expansions. Such evidence informs us about where and when expansion events happened. However, to answer the questions behind the "how and why" of hominin expansions, we need to examine concepts that offer explanations and lead to the case-specific formulation of hypotheses in need of testing; this is where modeling comes in.

We apply a wide spectrum of techniques, for instance stochastic modeling, environmental niche modeling, various statistical modeling procedures, and agent-based modeling. This permits us to select the most appropriate procedure to compare and test hypotheses in the context of particular expansion events. Regardless of which procedure is applied, the model requires us to formalize various components of theory. If we wish to examine how environmental change influenced hominin distribution patterns and whether it acted as a driver of hominin expansions in a particular case, we need to find formal expressions not only for the characterization of the ecospaces, but also for the requirements of hominins in specific habitats. Moreover, it is also necessary to formalize the various aspects of culture. In fact, the question of how to formalize the various aspects of hominin expansions constitutes one of the major research questions in ROCEEH.

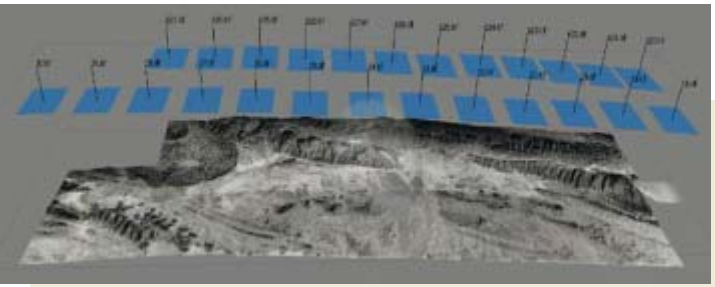

Fig. 12 Assemblage of stereo-aerial photographs (blue) from Mazayjan Basin, Zagros Mountains, Farse Province, Iran for derivation of a Digital Elevation Model using a range imaging technique known as "Structure from motion" (Graphic: R Zakerinejad)

Fig. 13 View of the Middle and Upper Paleolithic cave site of Sefunim in Mount Carmel, Israel (Photo: A. Fernandes)