

## The Nature of Culture Synthesis of an interdisciplinary symposium held in Tübingen, Germany, 15-18 June 2011

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**Abstract:** *The aim of the interdisciplinary conference ‘The Nature of Culture’ was to introduce and discuss in detail both a proposal for a concept of culture and a model of the course of cultural evolution. Primatologists, Paleolithic archaeologists, paleoanthropologists, and cultural anthropologists contributed to the interdisciplinary dialogue. The basis of discussion was the proposal of the concept of culture with biological, historical-social, and individual dimensions and a model for the expansion of cultural capacities. Invited papers assessed selected parts of the proposed concept and model. The result was widely agreed upon: an integrative concept of cultural capacity and cultural performance that accounted for the evolutionary processes involved, as well as a new model of the expansion of cultural capacity. Altogether six steps of expansion have been identified. The first three – capacities for socially transmitted information, capacities for tradition, and basic cultural capacities – can also be observed in some animal species today. Participants agreed to focus on the archaeological record as the key source of evidence documenting cultural evolution instead of ethologically derived features that are difficult to be traced archaeologically. The researchers in attendance defined three more cognitive extensions of cultural capacities during the course of human evolution:*

- modular cultural capacities, based on the ability to produce tools with tools,
- composite cultural capacities, based on the ability to combine different objects into single tool units, and
- collective cultural capacities, based on the ability to perceive a group (of agents, objects, persons, things) as an acting entity of interdependent parts.

**Keywords:** *Cultural evolution, cultural capacity, cultural performance, basic culture, modular culture, composite culture, collective culture*

**The Nature of Culture  
Synthese eines interdisziplinären Symposiums in Tübingen,  
Deutschland, 15.-18. Juni 2011**

**Zusammenfassung:** Das interdisziplinäre Symposium ‚The Nature of Culture‘ hatte zum Ziel, ein integratives Kulturkonzept und ein Modell der kulturellen Evolution vorzustellen und diese mit Primatologen, Archäologen, Paläoanthropologen und Kulturwissenschaftlern auszuarbeiten. Grundlagen der Diskussion waren der Vorschlag eines Kulturkonzepts mit biologischen, historisch-sozialen und individuellen

Dimensionen sowie eines Modells der Expansion kultureller Kapazitäten. Die eingeladenen Beiträge der internationalen Teilnehmer befassten sich mit ausgewählten Teilen der Vorschläge. Als Ergebnis wurde ein integratives Konzept kultureller Kapazitäten und kultureller Performanzen erarbeitet, das die unterschiedlichen Entwicklungsprozesse sowie Umweltabhängigkeiten einbezieht. Ergänzt wird dieses Konzept durch ein neues Modell der Expansion kultureller Kapazitäten. Insgesamt sechs Entwicklungsschritte wurden identifiziert. Die ersten drei – Kapazitäten für sozial übermittelte Informationen, Kapazitäten für Tradition und Kapazitäten für Basiskultur – werden heute auch bei einigen Tierarten beobachtet. Für die Modellbildung zum Verlauf der menschlichen Kulturevolution wurde vorgeschlagen, sich auf archäologische Hinterlassenschaften als Ausgangspunkt zu konzentrieren statt auf von den Verhaltenswissenschaften abgeleitete Merkmale, die sich archäologisch nur schwer fassen lassen. Drei zusätzliche Schritte der Erweiterung kultureller Kapazitäten im Lauf der menschlichen Evolution, die auf kognitiven Expansionen basieren, wurden identifiziert:

- Kapazitäten für Modularkultur auf der Grundlage der Fähigkeit Werkzeuge mit Hilfe von Werkzeugen herzustellen,
- Kapazitäten für Kompositkultur auf der Grundlage der Fähigkeit, unterschiedliche Objekte zu einer Werkzeugeinheit zu kombinieren, und
- Kapazitäten für Kollektivkultur auf der Grundlage der Fähigkeit, eine Gruppe (von Handelnden, Objekten, Personen oder Dingen) als Handlungseinheit mit voneinander abhängigen Teilen wahrzunehmen.

**Schlagwörter:** Kulturevolution, kulturelle Kapazität, kulturelle Performanz, Basiskultur, Modularkultur, Kompositkultur, Kollektivkultur

## Introduction

In the 20<sup>th</sup> and the beginning of the 21<sup>st</sup> century, the concept of ‘culture’ has become a frequently used, but controversial notion to describe special behavioral patterns. Regarded by most scholars as a uniquely human concept, in recent decades the term culture has also been applied to behavioral patterns of some animal groups such as whales and dolphins, and especially great apes including chimpanzees, orangutans and bonobos (e.g. Whiten et al. 1999; Rendell and Whitehead 2001; Hohmann and Fruth 2003; van Schaik et al. 2003). However, the meaning of the term ‘culture’ is quite diverse in its different fields of application. The social and cultural sciences use multiple definitions (Kroeber and Kluckhohn 1952; Hammel 2007) referring to cultural expressions of modern human societies. Other definitions are used to trace animal culture and emphasize the social transmission of information in contrast to genetic inheritance. Both approaches work on living organisms and the state of their directly observable behavior. Paleolithic archaeology and paleoanthropology, however, are not only interested in the static expression of cultural behavior at a given time. Rather, these fields examine the course of development of culture over long time spans, as well as the evolutionary and other processes involved. The research on these special aspects of cultural studies is complicated by the fragmentary record of past behavior that results from incomplete preservation, sampling biases, and limited analytical methods.

Several attempts have been made in the last decade to approach the concept of culture from a more integrative point of view. These attempts aim to understand “culture across species” (Byrne et al. 2004) and “the evolution of cultural evolution” (Henrich and McElreath 2003), to explore “the evolution of animal culture” (Whiten and van Schaik 2007) and the association of cognitive and cultural evolution (Haidle 2008a), to look for “a unified science of cultural evolution” (Mesoudi et al. 2006), and to gain insight in how “culture evolves” (Whiten et al. 2011). The authors discuss evolutionary aspects of culture using different definitions of culture, providing insight into mechanisms of cultural development and their evolution, supported by several case studies. These valuable studies showed that two elements are still lacking:

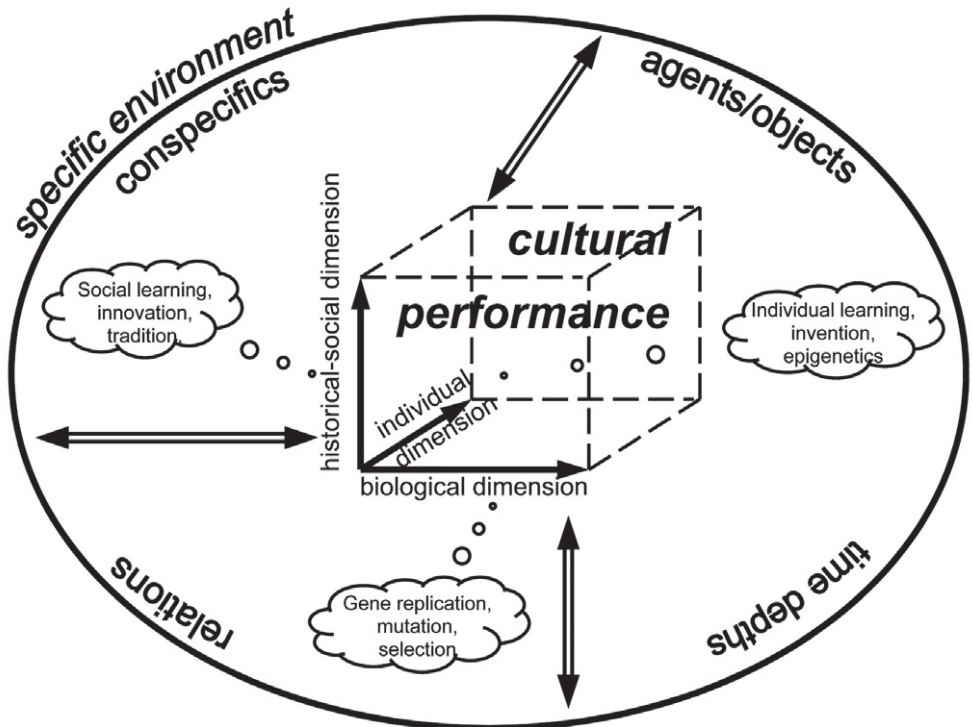
1) A concept of culture and cultural evolution that covers not only one comprehensive idea of culture, but different specificities of culture among, as well as within species. This view of culture should include several types of mechanisms that determine cultural variability.

2) A model of cultural evolution that associates the grades of cultural behavior identified in living animals with cultural changes over the course of human evolution.



**Fig. 1:** Speakers, the ROCEEH team and some guests of the symposium 'The Nature of Culture' (left to right from bottom): Andrew Kandel, April Nowell, Michael Bolus, Lyn Wadley, Naama Goren-Inbar, Marlize Lombard, Andrew Whiten, Christine Hertler, Miriam Haidle, Claudio Tennie, Anne Delagnes, Angela Bruch, Nicholas Conard, Mark Collard, Stephen Shennan, Thorsten Uthmeier, Shannon McPherron, James O'Connell, Marian Vanhaeren, Iain Davidson, Sibylle Wolf, Annette Kehnel, Michael Märker, Zara Kanaeva, Duilio Garofoli.

The aim of the international conference sponsored by the Deutsche Forschungsgemeinschaft (DFG) was to introduce and discuss in detail both a proposal for a concept of culture and a model of the course of cultural evolution. The symposium was organized by the research center 'The Role of Culture in Early Expansions of Humans' (ROCEEH) of the Heidelberg Academy of Sciences and Humanities and held at Schloss Hohentübingen from 15<sup>th</sup> to 18<sup>th</sup> June 2011. Primatologists, Paleolithic archaeologists, paleoanthropologists, and cultural anthropologists enhanced the interdisciplinary dialog (Fig. 1). The basis of discussion was the proposal of the concept of culture and the model of the expansion of cultural capacities. Invited papers referred to selected parts of the proposed concept and model. Summary blocks for each proposed stage of the model allowed ample room for debate, as did a mid-conference excursion to cave sites in the Ach Valley and the Urgeschichtliches Museum Blaubeuren. An evening lecture by Nicholas Conard (University of Tübingen, ROCEEH, Germany) set the model of expansions of cultural capacities into a regional context using the cave sites of the Swabian Jura as examples. In an intensive final round of discussion, the different preliminary statements, disciplinary views, intermediate summaries, and suggestions for improvement were brought together. The result was an integrative concept of cultural capacity and cultural performance that accounted for the evolutionary processes involved, as well as a new model of the expansion of cultural capacity which are summarized below.



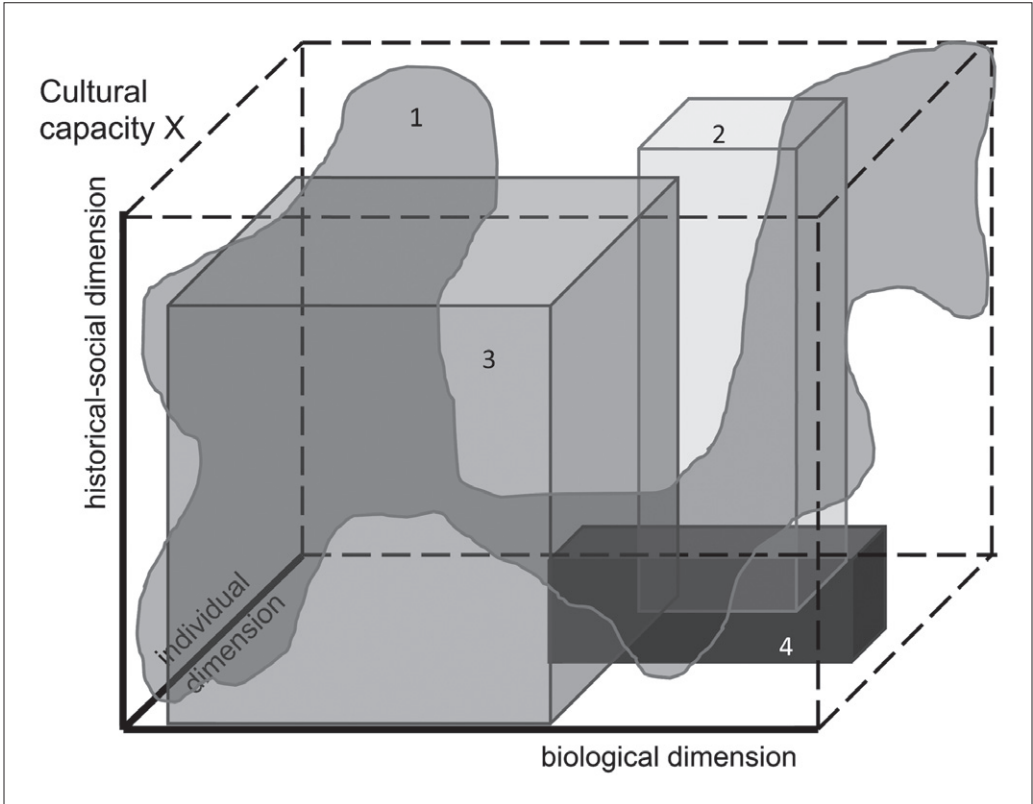
**Fig. 2:** Cultural performance with three dimensions of development, their main mechanisms and their embedding into the specific environment.

## Cultural performances and cultural capacities

The proposed integrative concept of culture differentiates between empirically traceable cultural performances and cultural capacity as a theoretical construct. Cultural performances represent the actual set of cultural attributes expressed by an individual, a group, or a population. They can be perceived partly in archaeological assemblages, as well as in the set of behaviors of living organisms. Three main dimensions of development determine the cultural performances of an individual or a population: a biological, a historical-social, and an individual dimension (Fig. 2).

The biological dimension comprises the biological potential and constraints for cultural behavior in genes, gene expression, anatomy, and physiology. This dimension is expressed, for example, in brain structure, sensory perception, motor and articulation skills, sociality, and the ability to communicate, with gene replication, mutation and selection as the principal mechanisms of continuity or change. The historical-social dimension represents the historical and social potential and constraints: the set of historically acquired knowledge and skills, the social access to the knowledge and skills, the ways and extent of storage, transmission, permutation, and transformation of the knowledge and skills. The principal mechanisms of continuity and change on the historical-social axis are social learning, innovation, and maintenance of tradition. The individual dimension incorporates the potential and constraints of an individual, or of a group of individuals, set by the personal social setting and individual life history of experiences. Additional mechanisms of change are effective on this axis and include individual learning, invention, and epigenetics. All three dimensions are multi-factorial and not fully independent. Rather, the three dimensions influence one another directly or indirectly via reciprocal effects with each other and with the specific environment. The specific environment is the sum of the cultural and the social environment of an individual, a population or a species plus the portion of the natural environment which affects or is affected by the individual, a population or a species (Haidle 2008b). Although the landscape of a lion and *Homo ergaster* may be the same, their specific environments differ markedly. These differences include the other conspecifics, the biotic and abiotic agents and objects that they affect or are affected by, the form of relationship with conspecifics/agents/objects, and the time depth in both past and future directions which influences these relationships or behaviors. Fig. 2 provides a rough sketch that accentuates the different developmental lines of cultural performance within this specific environment. Here cultural performance reflects neither a mere biological product, nor solely a historical issue.

While cultural performances represent the actual sets of cultural attributes expressed by an individual, a group or a population, cultural capacities represent the potential range of cultural performances in a species at a given time. Cultural capacities cannot be directly observed, but instead must be deduced from the sum of quasi-contemporaneous and conspecific performances (Fig. 3). The potential cultural capacities of a species are never completely exhausted by individuals or groups, rather different parts of them are used. The range of cultural performances, and thus the corresponding cultural capacities expand over the course of human evolution. Nonetheless, a single cultural performance in an advanced state of cultural capacity may be simpler than another performance in an earlier state, since different parts of the full cultural potential can be applied selectively (cf. Lombard and Parsons 2011). Although cultural evolution cannot be perceived as a

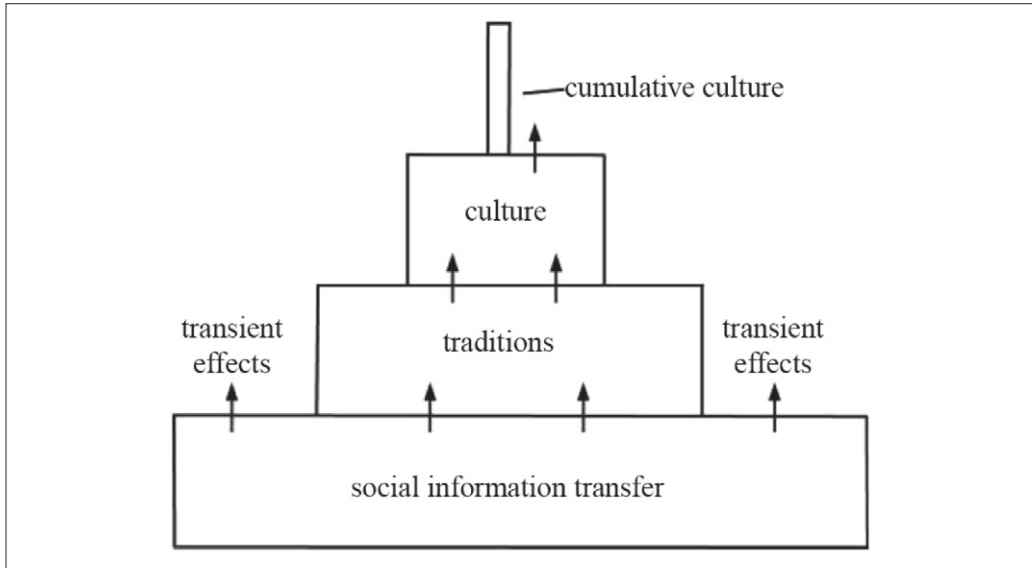


**Fig. 3:** Contemporaneous cultural performances (1, 2, 3, and 4) with different utilization of the three dimensions. Their maximal outline forms the cultural capacity.

clearly progressive development, the possible variety of cultural performances expands with increasing cultural capacity. The development of cultural capacities is a systemic process involving the co-evolution of the three dimensions and their interaction with the specific environment. While the evolution of cultural capacities is continuous, we were able to define six steps in the process of expansion, the first three of which can also be found in several animal species.

### **A new model for the extension of cultural capacities**

At the symposium, participants agreed that changes in biological, historical-social and/or individual factors do not produce ‘culture’ in a single creative event, in the sense that if chimpanzees possess culture, it exists in the same form as that of modern humans. Rather, these factors generate different cultural capacities with specific requirements and possibilities of expression. The ‘culture pyramid’ of Whiten and van Schaik (2007) (Fig. 4) constituted the seed that led to the formulation of an advanced model of the expansion of cultural capacities. Miriam Noël Haidle (ROCEEH) put this model up for discussion in her introductory paper.



**Fig. 4:** Culture pyramid as presented by Whiten and van Schaik (2007, 613, Fig. 4) identifying three layers of cultural behavior in animals: Social information transfer, traditions, and culture (as defined by the existence of multiple traditions forming unique local complexes in the same species). Cumulative culture with complex traditions that develop by elaboration on earlier ones seem to be limited to human cultures, with only minimal evidence in other species. The decreasing frequency of the different behavioral patterns is represented by the relative sizes of each layer. Arrows indicate the reliance of each layer on pre-existing, lower layers.

The three lower layers of the pyramid were adopted into the new model. A minor change in the renaming of the third layer from ‘culture’ into ‘basic culture’ signified a departure from the misleading use of the simple term ‘culture’ instead of a differentiation of cultural capacities. Andrew Whiten (University of St. Andrews, Scotland) explained these foundations on which hominin cultural developments are built and which can be observed in living animals. Socially transmitted information is a fundamental cultural factor. In the simple versions, these are instant data with no long-term impact on behavior, like in the waggle dance of bees. Traditions are behavioral patterns that have been transmitted through repeated social learning to become permanent characteristics of a group. The washing of potatoes in a group of Japanese macaques from the islet of Koshima is a famous example, but traditions have also been documented in fish and a number of bird and mammal species (Galef 2004). Basic culture consists of a number of traditions that differ among geographical groups. Additionally, these behavioral differences should not result from the mere effect of environmental conditions, such as the presence of a specific food source. Though behavior is learned from other individuals, the impulse to adopt features comes from the learner and remains individual. What is learned from others is a general focus on a specific result, but the precise sequence of actions is of secondary interest. This form of culture is restricted to a limited number of single behavioral patterns. Regarding animals today, at least chimpanzees and orangutans fulfill the prerequisites. The same can also be assumed for early *Homo* species and probably for some Australopithecines (Whiten et al. 1999; Rendell and Whitehead 2001; Hohmann and Fruth 2003; van Schaik et al. 2003; Whiten 2009).

In his talk, Whiten pointed to the need of dissecting cultural capacities in at least three fields: a) population level patterning, b) cultural content, and c) mechanisms of information transmission. He proposed this analysis not only for studies on living species, but also for the different levels of cultural capacities suggested for ancient hominins. Using archaeological artifacts as the basis for discussion, the preliminary ROCEEH model added three further levels of cultural capacity: a first expansion associated with the first hominin stone tools, a second expansion focused on cumulative cultural capacities as suggested in the culture pyramid of Whiten and van Schaik (2007), and a third expansion expressed in artifacts that serve as tools for communication, whose function requires not only an individual actor, but also a corresponding target group.

Iain Davidson (University of New England, Armidale, Australia) and Anne Delagnes (Université de Bordeaux I, France) debated the importance of early Paleolithic stone tools up to 2.6 Ma old with regard to an expansion of the cultural capacities beyond the basic cultural capacities documented in great apes. Davidson emphasized the close association of the development of cultural capacities with the evolution of cognition. He deplored that models of cognition are generally developed theoretically, thereby causing problems in their application to the archaeological record. In the first hominin stone tools he detects new cognitive and thus cultural capacities. In a detailed paper on “The Nature of Earliest Hominin Cultures” Anne Delagnes characterized different stages in early hominin use of stone tools before and after 2 Ma with extensions of raw material selectivity, raw material transport, flaking techniques, purpose of artifact use, habitat range, and dietary diversification. It was apparent in the discussion moderated by Mark Collard (Simon Fraser University, Burnaby, Canada) that the evidence from the archaeological record surpasses basic culture’s immediate response to problems, as observed in some animal species today. The use of tools to produce tools (secondary tool use), the intentional exhaustion of cores, and the increasing transport distance of raw materials all point to an extension of the distance of problem and solution in spatially, temporally, and cognitively different ways.

While the first level of hominin expansion of cultural capacities is recognized archaeologically, it is difficult to set into the concepts derived from ethological data. However, the proposed second level of hominin expansion of cultural capacities faces the opposite problem. The category of cumulative cultural capacities (Tomasello 1999; Tennie et al. 2009) was based on comparative research on primate and modern human behavior, yet this is difficult to identify in the archaeological record. Claudio Tennie and Shannon McPherron (Max-Planck-Institute of Evolutionary Anthropology, Leipzig, Germany) explained the cognitive and social foundations of cumulative culture. A main character is that changes are built upon one another and accumulate over time. Problems do not need to be solved again and again from scratch. Rather, solutions that are already available, but not fully fitting, can be adapted or further developed, comparable to a ratchet. The concept of cumulative culture is intimately connected with special forms of social learning – process oriented imitation and active teaching – both of which require an understanding of the ‘other’ as an intentional actor. Tennie, McPherron and their co-author David Braun suggest a late timing for the step to cumulative cultural capacities during the Late Acheulian. Based on the idea of strict accumulation without reinvention, they proposed an island test that could be applied to the archaeological record to prove cumulative cultural capacities. To distinct latent solutions within the species’ existing



cognitive repertoire from cumulative cultural behavior it should be tested if an invention occurs several times in different regions (latent solution) or if it is based on a specific accumulation of modifications over time (cumulative behavior). Criticism of the island test mentioned pyramids and domestication as examples of cumulative behavior that were independently invented several times.

Naama Goren-Inbar (Hebrew University, Jerusalem, Israel) presented evidence of a variety of cultural innovations at the Acheulian site of Gesher Benot Ya'aqov as an example of cumulative cultural capacities from the early Middle Pleistocene. In the discussion special emphasis was placed on the consideration of the entire cultural repertoire of a group instead of regarding only one artifact and the possibility of its invention by one individual alone. Marlize Lombard (University of Johannesburg, South Africa) objected to the ratchet mechanism in cultural evolution as proposed by Tomasello, Tennie and others because this would allow only unidirectional developments. In her talk she preferred to compare the mechanisms of cultural development with the act of mountaineering: it is always possible to proceed further from any point (like the ratchet), but returning to an earlier or simpler point can also proceed by retracing or following other routes. Using the mountaineering metaphor, cumulative cultural capacities do not only include those cultural efforts that are built upon the highest level achieved, but also apparent backsteps that are nevertheless derived from more advanced solutions. Lombard used the development of hunting weapons to illustrate the relevance of cumulative cultural capacities for an increasing technological, cognitive, and behavioral flexibility. The question was, however, which form of social learning would be necessary to construct a bow-and-arrow if process-oriented imitation and teaching were defining prerequisites of cumulative cultural capacities.

April Nowell (University of Victoria, Canada) unraveled the changes in life history in human evolution and the evolution of play. Applying an ontogenetic approach to human evolution she debated the role of play in the extension of cultural capacities. For early *Homo* including *Homo erectus* she suggested a first limited enhancement of fantasy play; modern grade fantasy play should have accompanied only cumulative cultural capacities. Formal or rule bound play may have been restricted to collective cultural capacities.

In the discussion the general transferability of the existing concept of cumulative culture as a step in the model of the expansion of cultural capacities was questioned. Three major problems were identified: 1) the traceability in the archaeological record, 2) the delineation of cumulative cultural capacities that are ethologically defined against preceding and successive cultural capacities that are archaeologically characterized, and 3) the idea of unilinear progress as implied by the ratchet effect and the island test. General caution was recommended not to copy the error of a drunkard who looks for his lost key only where there is light. Participants agreed that the model should not be limited to information known today, but that an abstract model of the expansion of cultural capacities should be presented. The stages of expansion should not be fixed to specific hominin species or periods, but rather completed with examples that show the current state of knowledge, and open to new finds and observations.

Cultural capacities beyond cumulative culture were proposed in the basic model for discussion. In collective cultural capacities, self-consciousness (with awareness of other intentional actors) is extended to group consciousness: "I am acting in a group with

others” can be shifted to “we as a group are acting”. Objectives are additionally set on a collective basis, and collective tools – especially communication tools and tools fostering group identity – broaden the behavioral spectrum. Symbolic artifacts such as ornaments, art objects, and musical instruments whose principal function or secondary purpose is the transmission of information, are closely connected to collective culture. To unleash their full potential, communication tools require not only individual producers and users, but also a related group of receivers and decoders of the messages. The more complex and coded a message is the more details about the code must be known to understand it. Well-informed circles begin to separate from groups of outsiders.

Lyn Wadley (University of the Witwatersrand, Johannesburg, South Africa) examined the question of cognitive manifestations beyond cumulative cultural capacities focusing on transformations. She suggested deliberate and irreversible transformations in technology, the heat treatment of rock and the production of compound adhesive, as the cognitive starting point for social and symbolic transformations. The cultural conferment of a new status to objects and humans may be materially expressed, for example, through the intentional breakage of things, body modifications, and deliberate marking. As the new status is rewarded by others, these social transformations require collective cultural capacities beyond individual solutions as in cumulative cultural capacities. Stephen Shennan (University College London, England) explained the importance of demographic parameters for the development of cultural capacities in general, and especially for new forms of collective actions. He emphasized the effect of demographic changes not only on innovation rates, but also on the rates of extinction of cultural items. Population size, however, is only one factor; other important measures are the rate and scale of interactions.

Thorsten Uthmeier (University of Erlangen, Germany) addressed the problem of evidence of cultural identity and collective cultural capacities in Neanderthals. While the technology of core reduction seems inadequate to recognize group identities, the treatment of surfaces yields better results. He found cultural norms in tools, but no tools to communicate cultural identity. Uthmeier concluded that Neanderthals showed only low-level group identity which was not deliberately expressed. This limited cultural identity may be the origin of the lack of widespread ornamentation representing social position, status, and prestige. Michael Bolus (ROCEEH) contrasted the Neanderthal evidence with evidence on collective cultural capacities expressed in stone and organic tools of anatomically modern humans of the European early Upper Paleolithic. He focused on the existing models that connect different types of style in artifacts with group and personal identity. While strengthening the importance of merely functional objects in the study of prehistoric identities, Bolus made clear that this can only be done in conjunction with data derived from other artifact categories, such as personal ornaments, decorated objects and art objects.

Marian Vanhaeren (CNRS, Nanterre, France) then showed the possibilities of studying personal ornaments to identify different cultural identities. The earliest forms of personal ornamentation are associated with anatomically modern humans in the Levant, North and South Africa, but also Neanderthals used shell beads with natural holes. In contrast, early Upper Paleolithic ornamental objects were artificially modified. The role of the beads may have been diverse in different regions: While in Africa the standardized

objects may have served as parts of an exchange system to reinforce reciprocity networks, in Eurasia they seem to have been used to represent group affiliation and social roles. In the final paper, James O'Connell (University of Utah, Salt Lake City, USA) examined the expansions of cultural capacities from a behavioral-ecological perspective. He drew the picture of changes in life history and consequent changes in social organization that led to larger social groups, loose mother-offspring ties, increased pro-sociality among juveniles, and greater opportunities for social learning. O'Connell questioned whether cultural capacities even developed in human evolution, or if all apparently cultural advancements were just mere consequences of change in the biological dimension, especially in life-history.

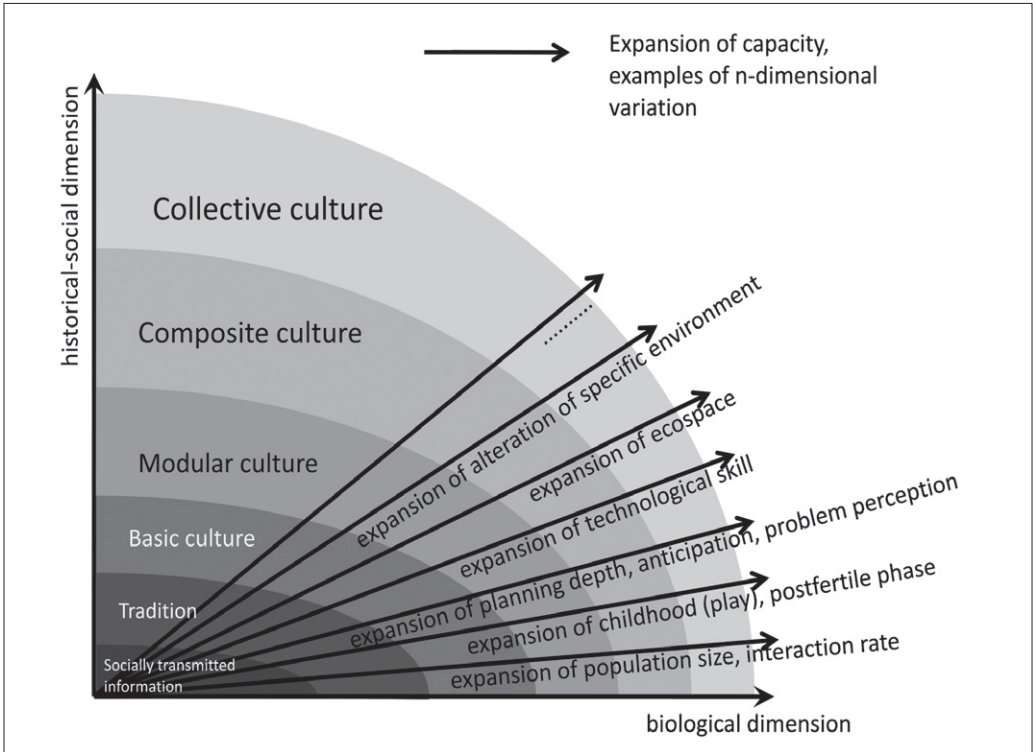
Closing the symposium, Christoph Antweiler (University of Bonn, Germany) assessed the level of discussion attained and the proposed model of expansion of cultural capacities from the perspective of a cultural anthropologist. Generally agreeing with the state of discussion reached at the end of the symposium, he suggested selecting terminology cautiously to make the model acceptable for all of the different disciplines involved.

The four-hour, final discussion summarized the current level of information, tied up loose ends, integrated objections and sketched a modified model of the expansion of cultural capacities. Participants agreed that the concept of 'cultural capacities' is more appropriate for studying transitions in cultural behavior than the simple term 'culture'. This allows a differentiated view on behavior based on socially transmitted information as observed in animals in comparison to cultural remains from hominins, focusing on the conditions of possibilities and limits for cultural expressions. Altogether six steps of expansion were identified, and these include achievements from earlier states (Fig. 5). The first three steps can be observed in some animal species today and equate to Whiten and van Schaik's model (2007) (see above, Fig. 4). For the course of cultural evolution in hominins, many of the participants suggested that research should focus on the archaeological record as the basis of evidence, instead of ethologically derived features that are difficult to trace archaeologically. As a result, three further steps were identified in human evolution with their basis in cognitive extensions.

**Modular cultural capacities:** If tool use is observed in the context of traditions and basic cultural capacities, it is limited to the ability to use unmodified or simply altered objects. In contrast, early flaked stone tools that are generally associated with hominins show an increased cultural capacity of modularization. With the ability to produce tools with other tools, tool use becomes increasingly flexible. Tools are not only fixed to a specific aim like fishing for termites. Rather, secondary tools (tools to make tools) like a hammerstone can be applied to a variety of different problems showing an increased level of abstraction.

**Composite cultural capacities:** New cultural capacities appear that enable the combination of different objects into single units, such as compound adhesives and hafted tools. This extension in technology has been seen as a critical cognitive step (cf. Ambrose 2010), but as such it is also an important expansion of cultural capacities. Composite tools are clear evidence of cumulative technological development because they combine independently existing ideas and solutions into a new concept.

Collective cultural capacities: The last step of extension of cultural capacities comprises several extensions in material culture based on the perception of a group ( of agents, objects, people, things) as an acting entity of interdependent parts, instead of as an assemblage of individually acting elements. Collective cultural capacities can be expressed, for example, in complementary tool sets like bow-and-arrow, with different elements developed corresponding to each other, and in communication tools, such as ornamental systems, figurative art objects, and musical instruments which reflect important expansions in symbolic communication.



**Fig. 5:** The expansion of cultural capacity. The model does not imply a progression of steps, but focuses on an extension of cultural capacity that incorporates the inclusion of achievements from earlier states. Only the two most influential dimensions of development, biological and historical-social, are represented. To simplify the model, the individual dimension has been neglected in this figure.

Table 1 provides a sketch of the steps of expansion of cultural capacities in hominins with information about the bearers and the dating based on our current knowledge. These general steps of expansions in cultural capacities are accompanied by expansions of various specific features and abilities including the alteration of the specific environment, the expansion of ecospace, technological skill, planning depth, anticipation, problem perception, play, an extension of childhood and of the postfertile phase, population size, and the interaction rate. It remains to be studied in detail which of these steps are basic expansions as part of the biological or historical-social dimensions sensu stricto

and which of them are caused by several components in cultural development. Here one should not expect to see clear causal links to either biological, historical-social or environmental developments, but rather a dynamic interaction of different causalities. Further research is also necessary to clarify for each developmental step the different ways and processes governing the transmission of information, the amount and form of information transmitted, and the set of problems that can be approached by socially transmitted information.

Cultural capacities	Artifact markers	Climate zones (current knowledge)	Earliest known evidence	Currently associated species	n-dimensional variation
Collective	symbolic + complementary tool use	arctic + arid	< 100 ka	<i>Homo sapiens</i>	...
Composite	composite tool use	cold temperate	< 300 ka	<i>Homo sapiens</i> + late archaics	....
Modular	modular tool use	warm temperate	< 2.6 Ma	early <i>Homo</i> + <i>Homo erectus</i>	....
Basic	basic tool use	tropical + subtropical	> 2.6 Ma	non-human primates, etc.	....

**Table 1:** Steps of expansion of cultural capacities in hominins.

The symposium ‘The Nature of Culture’ brought together specialists from natural sciences and humanities in order to develop an integrative concept of cultural evolution. The resulting model of the expansion of cultural capacities is groundbreaking in providing a theoretical framework to which different data on cultural behavior of animals, extinct hominins up to modern humans can be linked, directly compared, and studied.

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