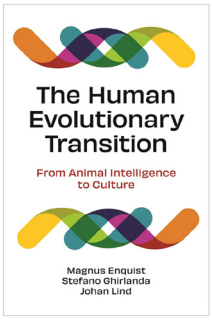
BOOK TITLE:
The human evolutionary transition: From animal intelligence to culture



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Becoming human: Expert sequential and flexible thinking led to cumulative culture

When, why and how humans started to think and behave in typically human ways is a topic that has long fascinated and vexed scholars of hominin evolution. The origins of 'behavioural modernity' are discussed and debated in a variety of fields – it is, for example, close to the hearts of archaeologists and evolutionary anthropologists working on the material cultural legacy of *Homo sapiens* and their ancestors in Africa.[1,2] This book provides a bold new theory on becoming human that considers why human intelligence did not evolve in other animal species. It is a refreshing perspective on the topic as it comprehensively reviews animal behaviour in a wide range of species, from rats to pigeons, octopuses, and elephants. Humans represent a small part of the animal kingdom, yet most animal behaviour, apart from that of higher primates, is never discussed in accounts of human behavioural evolution. This new theory emphasises how mental mechanisms relate to behaviour rather than the brain; this avenue of research is preferred as much more is known about behaviour than is known about the brain. It is hoped that this theory would avoid the disagreement and fragmentation characterising cognition and learning research by not relying on concepts such as cognition, intelligence, planning, and reasoning that are 'inherently slippery' to describe human and animal behaviour. However, a degree of conceptual ambiguity is probably unavoidable, as illustrated by the focus on 'intelligence' in this book.

A 'strong' mathematical theory – in the sense that it can generate empirical predictions – is put forward. A model of sequence learning based on information, learning and decision is created and a simulation environment is developed to specify experimental designs and mental mechanisms. Combinatorial dilemmas stand in the way of productive behavioural sequences as flexible solutions are costly and time-consuming. Enquist et al. suggest that natural selection would have restricted mental flexibility to decrease learning costs. Therefore, a cost–benefit analysis is an important component of the model that is used to evaluate whether a mental mechanism would have been a viable evolutionary solution to a problem.

An impressive number of animal studies conducted under controlled conditions, from the early 1900s until recently, are reviewed. The authors conclude that chaining through association is the mental mechanism accounting for learning in animals. Animals tackle combinatorial dilemmas by learning short sequences and simple algorithms, favoured by genetic predispositions and the ecological and social environment. The view that associative learning is frequently superior to human-type thinking is a welcome reminder of animal cognitive genius in a research field dominated by anthropocentrism.

Human thinking happens when information from different events is recombined, and causal relationships between events are remembered. Humans became experts in sequential information processing and mental flexibility. Mental flexibility involves a series of mental procedures and intermediate memory states that retain the results of mental processes – these components are collated into a behaviour. Adaptive filtering or the preferential retention of useful information is a crucial aspect of human intelligence. In human thinking, the combinatorial cost incurred by mental flexibility is offset by using culture as a "reservoir of mental and behavioural skills". In this way, individuals can learn skills far beyond what they can learn and discover for themselves, thus setting the scene for cumulative culture. This strategy enables humans to consider increased possibilities and overcome the combinatorial dilemmas that hamper the discovery of productive behavioural sequences.

Genetic evolution of abilities linked to faithful sequence representation and mental flexibility started the evolutionary transition towards human thinking. These changes would have been domain-general (not modular) and initially "almost behaviorally silent." Its full potential would have been realised through cumulative cultural evolution. Gene-culture coevolution would have been involved in changes related to inborn specific mental skills, for example those used to support language. A stable environment most likely created the ideal conditions for cumulative cultural evolution. Stable environments would have provided the opportunity for long sequences of behaviour to develop, which could be scaffolded into further complex behaviours. In modelling language, a stable environment would have provided a favourable entry pattern for the evolution of faithful sequence representation or sequential abilities. A further essential aspect in the evolution of human cumulative culture is longer and protected childhoods which supported active teaching and sharing of information. However, humans and animals share the inborn motivational and emotional systems that drive much of behaviour.

A crucial question is when the genetic grounding for mental flexibility and long sequence behaviour might have been in place. It is suggested that the last common ancestor of Neanderthals and *Homo sapiens* would have already evolved the brain capacity for cumulative culture. This is at odds with one of the major ideas that had previously dominated thinking on the evolution of modernity – that human cultural capacities developed as recently as 40 000 years ago in modern humans and spread through migration and contact. This idea is not as widely rejected as suggested in the book, but indeed the "rubicon expectations"[3] that assume that there would be clear archaeological markers for modern behavioural and cultural processes have proved to be less tenable. The computational theory put forward here agrees with models and theories that emphasise the importance of the demographic and social environments in the development of complex material culture.

This book was not intended to be a theory of everything, and the testable predictions could be fruitfully investigated further. This engaging account explicitly shies away from correlating behaviour with brain functioning. The fundamental general domain capabilities on which human culture rely remain a black box and there is thus ample scope for integrating biological brain evolution research to a larger degree. There is also much potential to link the hypotheses on flexible sequential thinking more extensively to archaeological material culture. The book focuses

mostly on impressive recent cultural expressions, such as playing chess, musical notation and monumental architecture. However, this represents only the most recent manifestation of cumulative cultural evolution, leaving fertile ground for further exploration of the archaeological cultural reservoir.

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