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by

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Economics with a Phylogenetic Signature

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Abstract

Ever since Darwin biologists have emphasised the commonalities between non-human and human species, while anthropologists have stressed the big difference between them. This paper not only endorses commonalities between species but takes them as a means to give extant phylogenetic differences a clear profile. It introduces the notion of universal culture, applicable to all phylogenies of culture-making species. Culture is defined as a system of socially generated and transmitted rules that allow their carrier cultural operations, economic operations taking centre stage in the study. Based on explorative induction – employing macaques washing sweet potatoes and 60,000-year-old ornamented ostrich eggs as exemplars – commonalities and differences between the cultures of non-human and human primates are highlighted. The hypothesis is advanced that non-human primates are capable of endosomatic culture, meaning that the origination of their culture is conditional upon a sensory nexus between the rule maker and the external referent; for instance, a tool rule is originated by inferring a tool function from the shape of a pre-existing stone. In contrast, humans can evolve exosomatic culture, as they possess the unique ability of imagination, which enables them to originate rules independent of any sensory nexus. Genetically equipped with the ability to use abstract language, humans can transmit rules both horizontally and vertically, not just as object-dependent templates but also as symbols. The possession of shared imagination is seen as representing the major proximate cause of the evolution of human culture, facilitating its distinctive economic operations.

1 Economics and phylogenetics

There have been many attempts to reassess the foundations of modern economics ever since its emergence in the second half of the 19th century, but none of them has been as radical in endeavouring to get the root of the problem as recent attempts to reconstruct the discipline on the basis of phylogenetics (Gowdy et al. 2013; Wilson 2012; Witt and Schwesinger 2013; Bowles and Gintis 2011; Ofek 2001; Robson 2011; Stoelhorst and Richerson 2013; Richerson and Boyd 2005).

The aim of this study is to make a contribution to economics along these lines, not to contribute anything to phylogenetics per se. It deals with issues of phylogenetics to the extent that they may contribute to our scientific understanding of the nature of the economy. In pursuing this aim, the analysis shares the confidence evinced by other such attempts that an enquiry along phylogenetic lines will indeed make a significant contribution in due course to the growth of knowledge in economics.

Looking at its fundamentals, economics is viewed as the science that studies culture under the premise of scarcity. The core of the following analysis may be captured with a simple question: why does the human species entertain a unique culture even though non-human primates and other animals display faculties that we all would associate with human culture? Charles Darwin argued that it “is notorious that man is constructed on the same type or model as other mammals” (Darwin 1871: 10), and that “there is no fundamental difference between man and the higher mammals in their mental faculties” (Darwin 1871: 35). If so, what then explains the spectacular difference in their cultures? In popular phrasing: if monkeys are that smart, why don't they have a culture that in its complexity even remotely resembles that of humans?

Coping with this question calls for a broadly construed enquiry into the phylogenetic commonalities between the human and non-human species, and it immediately invokes an analysis that reveals the essential differences between the innate abilities of the species compared. Embracing fields such as ethology, primatology, sociobiology, evolutionary psychology, genetics, epigenetics and evolutionary anthropology, we have available today a substantial body of literature to tap when dealing with the intricacies of the questions of phylogenetic commonalities and differences.

Attending to such a phylogenetic programme, economists are first of all called upon to act as gatekeepers, deciding which avenues should be considered relevant for their discipline and which

not. Taking on this role, the economist will employ criteria that arise from a particular vision of what represents the scope and subject matter of economics, and what constitutes the primal questions of its domain. Even a cursory inspection of current works attempting a phylogenetic approach demonstrates that the criteria for singling out the relevant questions from the irrelevant ones differ substantively.

2 Phylogenetic analysis as continuation of economics by other means

A major principle of economics that gives phylogenetic analysis its direction is rationality, or the rational agent. Neoclassical mainstream economics solves the allocation problem by employing equilibrium analysis premised on decision logic. To give decision logic teeth, the assumption of rationality is called forth. The model operates with a ‘representative agent’, who maximises expected utility under constraints given preferences, technology and institutions.

Taking the neoclassical model as the departure point of phylogenetic analysis, the agenda will be to furnish evidence for the ubiquity of decision logic and rationality as they shape behaviours and cultures across ancestral lineages (Bowles and Gintis 2011, Gintis 2005). Monkeys and other primates will be shown to display rational behaviour in the context of choice, which furnishes an animal template for the behavioural assumption for the economic model (Doris and Glimcher 2003; Real 1991).

From this vantage point, economics is viewed as having a natural affinity with biology as “biologists generally employ the same model in understanding the behavior of organisms” (Gintis 2005: 123; also Grafen 1999). The survival of an organism depends on how efficient its decisions are in a selective environment, rendering rational decision making the core concept of both biology and economics. As economics has pioneered decision theory and optimisation techniques, biology is seen to benefit from the importation of those concepts into its domain (Gintis 2005). The core of evolutionary biology in this view is not simply rationality but, more narrowly construed, rationality employed in decision making.

The idea of decision making is carried into the entire spectrum of the behavioural and cognitive sciences (whether evolutionary or not). As a case in point, standard cognitive psychology is rejected on the grounds that it “generally defines the brain as an ‘information-processing organ’, but in fact the brain is a decision-making mechanism, information processing simply being a necessary element thereof” (Gintis 2005: 123). As with rationality, information processing serves as the handmaiden of decision theory underpinning the economic model.

In another reading of economic theory, the focus is on cooperation and coordination as major organising principles of social groups. Using this theoretical map furnishes phylogenetic evidence that differs markedly from that obtained from an enquiry informed by the neoclassical paradigm. The evolved cooperative instinct and organisational abilities of humans are generally seen to account for the vast difference between non-human and human culture, and to shape the latter in a unique way (Gowdy et al. 2013; Wilson 2012). Some of the recent contributions have focused specifically on how innate social behavioural traits adapted to the production requirements prevalent in early human phylogeny have shaped the behaviours of individuals in modern corporations or business units (Witt and Schwesinger 2013; Stoelhorst and Richerson 2013; Cordes et al. 2010).

A major aim of the subsequent analysis will be to determine the force of the arguments put forward in the competing approaches.

3 Methodological problem I: phylogenetic depth

For phylogenetic analysis to become useful for economic theorising it has to be able to tackle two major methodological problems.

The first concerns the ‘phylogenetic depth’ employed in the enquiry of the ancestral lineage. Put differently, the issue is one of earmarking the particular branches of the ‘tree of life’ when investigating the phylogenetic roots of human behaviour. One research strategy is to define the phylogenetic depth in relation to early human phylogeny; another is to employ an inter-species perspective embracing non-human primates and other animals. The priority given to a particular strategy depends, naturally, on the theoretical questions that are posed.

The former strategy aims at demonstrating “how innate social behavior traits evolved in early human groups” and how these “are still present in modern humans and leave their ‘phylogenetic footprints’ also in present-day”, till example, “organizational life” (Witt and Schwesinger 2013: 533). Evidence gathered from early human phylogeny is frequently seen to display a ‘mismatch’ in capabilities calling for organisational designs and policies appropriate for tackling modern problems (Stoelhorst and Richerson 2013; Witt and Schwesinger 2013: 543–544). Phylogenetic analysis of this strand moves within the intra-species domain (of human phylogeny), opening the phylogenetic door to inter-species evidence only occasionally.

The latter approach expressly crosses the line to non-human species and singles out one or several species for phylogenetic comparison. The human species is portrayed in terms of its unifying characteristics, with little attention being paid to differences between early and late phylogeny. Different branches of the tree of life are visited when enquiring into phylogenetic commonalities and differences.

Pursuing this approach begs the question of why an extension of the domain beyond human phylogeny should in fact contribute anything to our understanding of human behaviour. On a quantitative scale, an immediate knowledge gain shows up clearly when it is considered that extending the observational scope goes with a broadening of the inferential base. The large variety in behaviours between and within non-human species provides us with a rich 'phylo-inductive' source for economic theorising.

There is also the more specific question, however, of whether there is a relationship between phylogenetic depth and the possibility of drawing interesting cognitive and behavioural inferences. Generally, the total explanatory domain comprises all possible commonalities between non-human and human species with regard to cultural abilities. The boundary values of the domain are the human species (the reference value) and those non-human species that occupy the most distant branches of the tree of life. In this way, chimpanzees are close to humans, macaques branched off earlier and capuchin monkeys are earlier again than these in the phylogenetic lineage. The suggestion is that commonalities between human and other species have *ceteris paribus* the more weight in explaining the ultimate cause of human behaviour the larger the distance in the phylogenetic lineage. Accordingly, commonalities with capuchin monkeys are particularly interesting, since they branched off about 40 million years ago, while chimpanzees and humans still had a common ancestor perhaps as recently as 5 million years ago.

An interesting case is provided by species that are phylogenetically very distant from humans, such as social insects, but that have outstanding abilities nonetheless with regard to behaviours we consider constituent for human culture. For instance, ants show remarkable organising capabilities, and therefore may serve as a phylogenetic template for organisational tasks in human culture.

The existence of high-performing species that are distant ancestors suggests a need to take the *ceteris paribus* clause alluded to quite seriously. "The appearance of similar abilities in distantly

related species, but not necessarily in closely related ones, illustrates that cognitive traits cannot be neatly arranged on an evolutionary scale of relatedness” (Bolhuis and Wynne 2009: 833).

For this study, the question of particular interest is how phylogenetic findings may contribute to a better construction of economic theory. At this juncture, we may gain from them two insights suitable for the task. First, notwithstanding all behavioural excellence, we observe that the distance between human culture and that of social insects such as ants is strikingly large. Precisely because ants are so excellent in performing a particular task, this suggests that there are further distinct abilities necessary for human culture. Furthermore, as we shall see, other species such as monkeys are recorded exhibiting extraordinary faculties in generating different kinds of cultural behaviors, such as tool making. They lack high performance in other abilities, however, such as the organisational abilities of ants. Both kinds of species excel in different particular abilities; but they both fail in terms of performing adequately in the related abilities that are a prerequisite for human culture.

The composite evidence provides us with a preliminary cue about the nature of human culture – where all economic operations reside. There exists a set of distinct abilities, all of which constitute necessary conditions for human culture. They cannot be substituted, as they are fundamentally complementary. As we shall see, meeting the demands of complementarities is responsible for major differences in the cultures of human and non-human species.

4 Methodological problem II: rider and horse

The second methodological problem does not concern the empirical base but, instead, revolves around the issue of perspective, the proper identification of theoretical questions. What are the economic issues worthy of phylogenetic enquiry? As remarked at the outset, phylogenetic analysis is only a means for economic theorising, not an end in itself. By way of a metaphor, economics is the rider, phylogenetics is the horse. Echoing a saying attributed to Sigmund Freud, if we asked an economist “Where are you riding?” we would not expect him or her to answer “Ask my horse”!

This leads us to another question: what kind of theory should an economist adopt when giving the horse its direction? As we may conclude from the preceding discussion, there are various theoretical approaches that economists may consider as qualifying them to direct the horse.

Looking for orientation, we may focus on the relationship between the rider and the horse rather than looking only at the role of the rider. As any rider knows, winning a concours is impossible unless an intimate relationship between rider and horse has been established. In the present context, the issue is whether the role of phylogenetics must necessarily be confined to the obedient horse responding to pre-given theoretical questions, or whether it may also play a more constructive role by framing and posing the questions. There are thus two distinct, though complementary, approaches to using phylogenetics in economic theorising. One is to use it for answering theoretical questions on the basis of its evidence, the other is to use that evidence for directing or redirecting theoretical questions. Both build on induction, but the former is confirmatory while the latter is exploratory, with a view to posing theoretical questions.

I adopt the exploratory course. I suggest that, by following this course, phylogenetics offers us rich potential for rethinking the empirical base of economics, and even, perhaps, for reconstructing it from scratch. Following a confirmatory course instead – merely raising extant theoretical controversies to a higher phylogenetic plane – would mean missing out on a unique historical opportunity for rethinking the status of the discipline.

Adopting an exploratory stance requires defining the theoretical position in a non-dogmatic way. It is a theoretical edifice in a permanent state of construction, with a view to continuous improvements. It is much like an open-source programme – a kind of theoretical Linux. We must remind ourselves, however, that phylogenetics is still the horse, and the basic theoretical positions have to be made clear.

In the following I first identify the theoretical core concepts of culture and of evolution – the twin pillars of the economics science I have in mind.

5 Culture: What it excludes and includes

The concept of culture is ‘a many-splendored thing’, and it is paramount for an adequate phylogenetic account to get its meaning straight from the onset. I define culture as a system that enables a population of a species to survive and evolve on the basis of continuous interactions with the environment based on socially generated and transmitted knowledge. This is a very general definition of culture, and it may perhaps occasion surprise how much it excludes.

Significantly, it excludes non-evolutionary approaches, as the concepts of generation and transmission are at the heart of an evolutionary process. Anthropology traditionally assumes a

static posture, analysing the singular case at a time or period. It often adopts a comparative view, highlighting not just the differences but particularly also the commonalities, which has eventually led to structuralism, exemplified in the seminal work of Claude Levi-Strauss. Under this aegis, studies employing an evolutionary approach came to be marginalised under the rubric ‘evolutionist’, rendering the standard model of anthropology deficient in terms of a dynamic core (Bondarenko 2007; Cronk et al. 2000; Carneiro 2003).

Recent works by biologists and evolutionary anthropologists have adopted a very different approach to culture, proposing a phylogenetic continuity of cultures. “Among biologists and an increasing number of anthropologists, there is general consensus that an inclusive definition of culture should reflect a continuity between animals and humans” (Krützen et al. 2005: 8939; also Whiten et al. 1999; van Schaik et al. 2003). The phylogenetic view leads to a very wide meaning of culture, but at the same time allows each culture to be given a particular profile by locating it specifically on the continuum.

It should be noted that the unified concept of culture excludes any notion of culture as being a subsystem of some larger, say social, system, in which culture connects with other subsystems such as the economic one. As a relevant case in point, in many empirical works in economics ‘cultural factors’ (often taken to be identical with ‘ethnic’) are related statistically to economic performance variables such as productivity, economic growth or distributional equality. While these works often provide interesting insights, the concept of culture serves here only as a taxonomic device with little theoretical meaning attached to it.

In the following, three building blocks are put forward that may be considered essential for constructing a unified theory of culture. In doing so, I draw heavily on some previous works (Dopfer 2004, 2005, 2011; Dopfer and Potts 2008). All cultures, such as that of chimpanzees, macaques, capuchins, bonobos and – come to that – humans, may be stated in terms of the universal categories proposed.

First, culture may be conceived as a system of knowledge that is used for cultural operations. In a distinction relevant for this study, cultural operations are either economic or non-economic. Economic operations include production, consumption and exchange. Simple as this exposition may be, it allows us to draw a distinction between two major levels of economic analysis:

knowledge level knowledge for economic operations

operant level operations based on knowledge.

Second, major theoretical issues revolving around the notion of knowledge may be dealt with adequately on the basis of what shall be called a *unified rule approach*. A *rule* is conceived as a semantic ‘bit’ or content, such as an idea, that enables its carrier to perform economic operations. *Information* is a rule that is available for adoption but has not yet been adopted; it represents a potential. *Knowledge* is rule information that has been adopted by a carrier; it represents an actualised potential. Members of a culture perform operations employing a knowledge base stated in terms of rules.

The concept of ‘rule’ (and its adjunct term ‘carrier’) can be employed on *three levels of theoretical analysis*. Methodologically, they designate different degrees of generality:

- **Level 1: Organic rules**

At the most general level, the broad expanse of the term ‘rule’ allows us to address the theoretical concepts that biology and culture share – as “*General Living Systems*” (Bertalanffy 1968) - on the basis of a unified concept. At this level we have biological rules and cultural rules. The general-theoretical concept of rules pertaining to living systems excludes explicitly *law-like* rules such as those of classical physics or mechanics. They are not mechanistic but rather (echoing North Witthead’s “Organic Philosophy”) *organic* rules.

- **Level 2: Cultural rules**

At the next, lower, level we may define culture as a rule system allowing for the above-mentioned distinction between rules for *economic* operations and those for *non-economic* ones.

- **Level 3: Economic rules**

Finally, at the bottom of the hierarchy of generalisations we have economic rules posited in taxonomy, denoting the various operations in an economic system.

In economics, the concept of ‘rule’ has made various appearances – for instance, as rule-following behaviour, institutional rules or quantity rules in monetary policy, etc. – but as an approach that embraces the ambition of unifying various areas or aspects it has made little in the

way of inroads in the discipline thus far. There are, however, some notable exceptions recognising its potential (Ostrom and Basurto 2011; Blind and Pyka forthcoming; Grebel 2012; Beinhocker 2011; Safarzyńska et al. 2012; Bleda and del Río 2013).

Third, culture is conceived as a system in which artefacts take centre stage. In biology, animals exchange natural objects with their environment, but, in culture, objects are produced by animals themselves. The existence of artefacts is therefore a characteristic of culture setting it apart from systems analysed in biology.

Some of the major abilities enabling animals to make culture are discussed in the subsequent section. By analysing observational studies by primatologists, various commonalities among animals will show up. The phylogenetic evidence gathered is intended to build up an empirical base for inferences about cultural abilities that are considered universal. Human culture will show up as the most complex form of culture that has evolved thus far.

Following on from this, all cultural abilities of animals are conceived as being manifest in their universal faculty to make cultural rules (or, simply, rules). Animals have a biological predisposition to make rules; for example, they make rules for production, upon which they perform operations of production. They do not simply produce artefacts; they produce rules enabling them to produce artefacts. The generation of knowledge precedes its operational use.

Alternatively, a direct relationship between biological predisposition and operations has been proposed. Cultural evolution in this perspective takes place as a phenotypic expression of biologically inherited abilities. Culture here is not a phenomenon in its own right but a phenotypic expression at a particular time and consequence of biological evolution along a secular time scale.

Contributions along this line include works of sociobiology (Lumsden and Wilson 1981; also Barash 1977), but also more recent works that are ready to emancipate the cultural aspects emphasising that culture evolves ‘not by genes alone’ (Richerson and Boyd 2005; Durham 1991).

Recent epigenetic approaches have received particular attention, as they highlight the causal nexus between biological and cultural evolution by way of the genetic transmission of acquired traits. “It postulates that a causal-mechanistic interaction exists between the processes of individual development and the processes of evolutionary change” (Müller 2005: 92; also Wagner

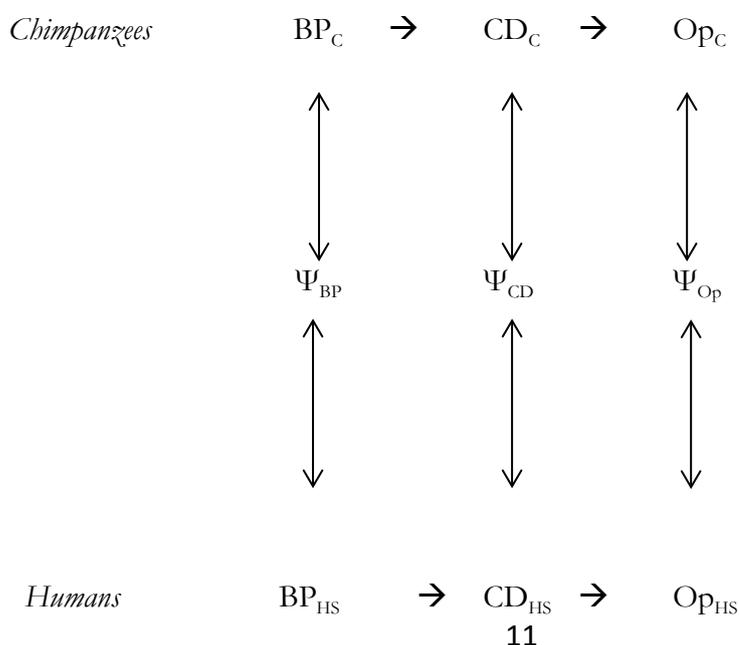
et al. 2005; on cultural science, Callebaut 2011). Although the former approaches are essentially Darwinian, the latter are expressly Lamarckian, though they integrate Darwinian selection.

At the cortical level, evolutionary psychology suggests that human cognition and behaviour are determined by modules that have evolved in the course of phylogeny. The modules have evolved into a biological predisposition that functionally governs operational tasks. “It suggests a mind populated by a large number of adaptive specializations, each equipped with content-rich representations, concepts, inference systems, and regulatory variables, which are functionally organized to solve the complex problems of survival and reproduction encountered by the ancestral hunter-gatherers from whom we are descended” (Cosmides and Tooby 2013: 201).

These contributions are milestones in the development of our understanding of the evolution of culture. They are rooted in the discipline of biology and aimed at gaining an understanding of culture from its perspective. In contrast, I have taken culture as a departure point suggesting that an acquired rule disposition governs cultural operations. Viewed from this vantage point, the pivotal question becomes how that cultural rule disposition is determined biologically.

In its core, my proposition is as follows: all culture-making animals exhibit a biological predisposition, on the basis of which they acquire a cultural rule disposition that they use for operations.

We may unpack this relationship by way of a simple exposition, using chimpanzees (C) and humans (HS) as exemplars:



BP stands for biological predisposition, CD for cultural rule disposition, Op for cultural operations and Ψ for phylogenetic distance.

Recalling the section on ‘phylogenetic depth’, there is no simple linear relationship between the locus of a species in the phylogenetic tree and its abilities for culture.

Turning to humans as species on the phylogenetic tree, we get *Homo sapiens* (HS; or *Homo sapiens sapiens*, as distinct from other hominids, such as *Neandertal*). Being a culture-making species, we get *Homo sapiens as a rule maker and rule user*. The members of this species acquire a cultural rule disposition upon which they operate, generating a distinct culture.

For HS operating under the pressure of scarcity – which we have stated to be the defining criterion of economics – we get by operational specification:

Homo sapiens oeconomicus (HSO)

In economics, HSO has not made a general appearance, but its different aspects have been highlighted variously – such as, for instance, as a ‘complex individual’, coping with problems of structural complexity (Davis 2008), or as ‘*Homo creativus*’, coping with challenges of unpredictable change in evolving environments (Foster 1987).

At this juncture it is important to note that HSO differs radically from *Homo oeconomicus* (HO), as adopted in mainstream economics. *Homo sapiens oeconomicus* – being ‘wise’ (*sapiens*) – is a rule maker, and the generation, adoption and retention of cultural knowledge is at the heart of economic theory. Traditional HO disposes of all knowledge (the rationality assumption, transparency about an externally provided opportunity set, etc.), and the domain of interest consists of the operations performed under the assumption of relevant omniscience. Recalling the distinction between the knowledge level and the operant level, rule-based economics deals expressly with the former, neoclassical economics with the latter.

An enquiry into the biological predisposition for culture builds on the disciplines mentioned, including genetics, epigenetics, evolutionary neurophysiology and psychology. For the purposes of this study, it must suffice to identify two faculties (whereby the term ‘faculty’ is taken to denote a family comprising several cultural abilities). The faculties are considered to constitute

culture in general. Variety between cultures is attributable to differences in abilities within the general faculty to entertain culture.

The first is the cognitive faculty. It embraces all cognitive abilities required for making and using rules, which include in particular rationality and imagination. Neurophysiologically, the cognitive abilities are generally located in the neocortical areas of the brain, with the major differences between humans and other rule-making species being attributed to the specialisation of the frontal lobes of the cerebral cortex of the former (Changeaux 1997; Damasio 2010; Eccles and Zeier 1982).

The second faculty has to do with non-cognitive mental abilities. In contradistinction to cognitive, we call them mental (giving the word ‘mental’ a narrow meaning) abilities. The core of this faculty revolves around motivations, emotions and will (Gerschlager 2012). They find their complex expression in the concept of intentionality, which not only provides us with essential cues about the direction and drive of cultural evolution but also shakes off biological determinism from cultural analysis (on a “science of intentional change”: Wilson et al. forthcoming).

6 Evolutionary principles of culture in their own right

How does culture evolve? How does the economy as a specific operational expression of culture evolve?

When looking for explanations of economic evolution, biology had paradigmatic significance right from the outset. Darwin himself proposed that the explanatory principles applicable in biology might be also of great use when looking for explanations of cultural evolution. In economics, Thorstein Veblen suggested that if economics was to become a modern science it had to follow the biologists’ lead and apply Darwinian principles (Veblen 1898). In our times, biology philosophers and biologists have proposed employing ‘universal Darwinism’ as an overarching paradigm for all sciences (Dawkins 1983; Dennett 1995). Inspired by Veblen’s early contribution and the philosophers’ view, ‘universal Darwinism’ has been also advocated in economics (Hodgson and Knudsen 2010). While the proposal lent steam to the discussion, the idea that Darwinian principles should represent the explanatory core of a theory of economic evolution has also invited criticism from various corners (Levit et al. 2010; Callebaut 2013; Cordes 2006; Witt 2004; Geisendorf 2009). It is fair to say that the discourse thus far has divided the views of

the community as much as it has created a consensus about the nature of evolutionary principles for economics.

Irrespective of the dissent, all views still share the position that biology represents the central paragon around which the discussion should revolve. This stance may be explained by the fact that the paradigmatic point of reference of mainstream economics has traditionally been mechanics, a branch of classical physics. In this context, biology may be seen as serving as a *counter-paradigm*, challenging dominant mechanistic thinking in economics. As Alfred Marshall famously remarked, biology, not mechanics, should be the Mecca of economics (Marshall 1920 [1972]).

Although the merits of biology as paradigmatic guidance are undisputed, the key issue of whether or not biology is the right departure point for a theory of cultural evolution is still open to debate. There is an alternative position, challenging the usefulness of homologies in general and arguing that principles considered valid for explaining cultural evolution are still valid even if they prove invalid in biology, and vice versa. Richard Nelson and Sidney Winter adopt this position throughout their seminal work on evolutionary economics (Nelson and Winter 1982). Stanley Metcalfe makes the point explicitly by contending that “[n]othing...is intrinsically a matter of biological analogy, it is a matter of evolutionary logic. Evolutionary theory is a manner of reasoning in its own right quite independently of the use made of it by biologists. They simply got there first” (Metcalfe 1998: 36).

This goes to the heart of the matter. Let us take Metcalfe’s remark that biologists “simply got there first” as inspiration for a *Gedankenexperiment*, which will inform our subsequent endeavour of providing building blocks for a general evolutionary theory of culture. Giving the question a counterfactual twist, it may be asked: what would have happened if economists had got there first? Tailoring the question for our purposes: what kind of evolutionary theory of culture or of the economy would we get if we ignored biology? Of course, we cannot erase extant knowledge, nor do we intend to ignore the fact that economists were dealing with evolution well before Darwin. Even so, the heuristic device may be useful, as it obliges us to concentrate on the subject matter in a radical way not conceivable when applying an approach that is premised on universal principles derived from biology.

The question then is: where shall we go from here? As indicated at the outset, there is an alternative approach, namely adopting exploratory induction instead of relying on deductive

schemes. The theories that make their appearance in this approach are not written with the letter ‘T’, indicating that questions and answers are issued ‘from above’, but, rather, with a ‘t’, setting a course of enquiry wherein several small theoretical concepts are employed when inspecting the empirical base. Pursuing a course of exploratory induction, questions and answers are, essentially, a product of the process of enquiry itself.

The procedure is reminiscent of an approach that raised controversy in economics in the 1980s. It criticised the general tendency in modern economics to take methods of quantification and econometric modelling as the sole benchmark for posing questions and evaluating answers, thereby ignoring the eminently qualitative nature of many economic phenomena (McCloskey 1983). The alternative approach advocated was one of replacing M-methodology by several hand-tailored m-methodologies. I follow the sister approach, not only in its distinction of assignments but in endorsing its critical posture as well, by proposing to pursue analogously an enquiry with a ‘t’ instead of a ‘T’.

7 Evolutionary principles as if phylogeny mattered

In our investigations into the principles of cultural evolution, let us start with the assumption that there exists a population in a species of social animals in which at least one member (or possibly many, or all) has the ability to make artefacts or some equivalent. Evolution then will originate if some member introduces into that group a novel rule for operations. By way of an example, macaques on the Japanese island of Koshima have been observed washing sweet potatoes, first in a creek and later in the ocean (Kawai 1965). The method of washing sweet potatoes was not pre-given to the macaques; the information appeared only when one conspecific invented the method. The operational capability of washing was not genetically determined but was made possible on the basis of the ability to generate a rule of washing, based on the biological predisposition to make rules.

The knowledge of washing sweet potatoes was not confined to the inventor but spread over the entire macaque population. The animals possess the inborn ability to adopt the available rule information. Based on this ability, the washing rule could diffuse across their entire population. Within five years (after the first observation in 1953) 80 per cent of the younger members – though only 18 per cent of the older ones – had adopted the washing rule.

Adoption is a concept we consider central to the analysis of cultural evolution. It involves a complex process of communication based on the ability to encode and decode information, on

the one side, and to accommodate that information into an extant knowledge base, on the other side. A simple transmission or replicator concept, with its possible analogue in biology, does not capture the nature of the process.

The macaques have observed the washing of sweet potatoes by conspecifics and understood the operational significance of the activities. They have decoded the rule of washing. The information was first encoded by the originator and then decoded by the conspecifics. The macaques know the language of coding, enabling them to both en- and decode the washing rule.

Finally, the macaques did not confine the usage of the washing rule to a single operation but repeated it over time. The adopted rule was retained for recurrent operations. The washing rule became a habit of the macaques. At the instrumental level, it determined as a routine and, at the social level, as an institution the recurrent operations of the group.

The rule was transmitted not just horizontally, by way of adoption at a particular time, but also vertically, over time, preserving the washing culture for generations. Horizontal and vertical transmissions are both a constituent characteristic of culture.

All interpretations of the evolution of a culture of washing in a macaque clan are utterly native to evolutionary economists, and, in fact, little could have been said without being familiar with this strand.

The fact that the nature of a non-human animal culture may be captured on the basis of principles established for explaining the evolution of a human economy demonstrates the close homology between non-human and human culture. Recognising this homology, the dynamic sketched may be represented on the basis of a universal trajectory composed of three distinct evolutionary mechanisms. They relate respectively to

- 1 origination of the rule;
- 2 adoption of the rule; and
- 3 retention of the rule.

The notion of trajectory acknowledges the irreversible order in which the mechanisms become effective: origination is necessarily prior to adoption, which, again, is necessarily prior to

retention. The mechanisms are posited as phases expounding the historical nature of cultural evolution.

Various observational studies allow us to furnish additional empirical flesh to the evolutionary trajectory. For instance, evidence from chimpanzees of the Taï National Park in Côte d'Ivoire helps us in elucidating the vertical transmission of nut-cracking rules characteristic for retention. The chimpanzees have been reported to meet at a place where they have employed tools for cracking nuts over many generations. Not only do young chimpanzees there watch the operation of nut cracking from their mother, but the mothers also instruct the youngsters as to how to use a stone hammer (Boesch 1991). They share the produce with them after the operation, and by so doing allow the young chimpanzees to acquire social rules of equitable distribution.

The case of using solid objects in production (rather than water from the ocean) is particularly instructive, as it makes possible 'animal archaeology'. In the area of Nuolo, a nutcracker production site was excavated in which the stone tools were up to 4,300 years old (Mercader et al. 2007). The findings date back to a time when humans lived in the late Stone Age, which means that chimpanzees and humans have used the same substrate for their material culture. This fact is noteworthy, as it means that differences in cultures cannot be primarily attributable to their material base.

Cultural evolution is dependent on many specific abilities, which observational evidence suggests monkeys all have. For instance, culture is critically dependent on the improvement of the implements it employs. To this end, an immediate step is the refinement of an extant tool. As an example, capuchin monkeys in the Serra da Capivara National Park in Brazil were observed removing the leaves and side branches from a branch so as to make a fine end to the resultant stick, which they used then as a tool.

Additionally, the functional range of a tool determines its effectiveness. The capuchins and chimpanzees not only refined their sticks but used them also for various purposes – as 'multi-purpose technology' – such as fishing for small arthropods or getting honey from a hidden nest (Ottoni and Izar 2008; for chimpanzees, Boesch et al. 2009).

A further step towards improving production is made when a technique is introduced that, ever since Adam Smith, economists have called the division of labour. In this production form, the production process is divided into several smaller steps in order to improve the intended end

result. In the above-mentioned studies of non-human primate production, and in others as well, various forms of dividing labour have been reported. By way of an example, chimpanzees in the Loango National Park in Gabon were observed using as many as five different sticks to get honey: one for raking in an underground bees' nest, a second one for making a hole into it, a third for enlarging the entrance, and two others for dunking and scooping the honey from the nest (Boesch et al. 2009; Whiten 1998). The logic of the technology consists generally in breaking up the production sequence into several sub-tasks for which different tools, such as sticks or stones, are employed.

The division of labour may be further advanced by using tools for the production of tools. Real capital is used to produce real capital. This form of 'capital-intensive' production is performed by capuchins in the Serra da Capivara National Park, which are reported to use small stones for excavating larger stones (Ottoni and Izar 2008). The search for small stones (the first production stage) antecedes the excavation of big stones (the second production stage).

A further, still more complex, form of dividing labour is based on a combination of various heterogeneous tasks. In this case, a production process is not decomposed into its partial tasks, which then are recomposed. Instead, the division of labour starts with a structure that designates a number of heterogeneous tasks to be accomplished. While this advanced form of the division of labour is a characteristic feature for industrial economies, there is observational evidence from various species that they employ it as well, for instance when engaging in hunting.

The logic behind the division of labour deployed in hunting may be demonstrated on the basis of observations made with chimpanzees in the Tai National Park (Boesch 2002). The members of a group, which may differ in size, perform different tasks related to different functions in the hunt. The target of the hunt is, 90 per cent of the time, red colobus monkeys, but other animals such as bush pigs are also part of the chimpanzees' diet. The hunt starts by separating the target animal from the group and narrowing its territory by steering it to a relatively isolated tree (the chaser's task). One or several chimpanzees then climb up the tree (drivers) to force the prey down. Other members of the group sit in the crowns of neighbouring trees to prevent the hunted monkey escaping to another tree (blockers). Some hunters may sit at the foot of the neighbouring trees to catch the victim if it climbs down (ambushers). Once the prey has been caught it is killed and distributed by the chaser to the other members of the group. Given the complexity of the task, male chimpanzees (females usually do not participate) start learning the hunting rules at about the age of 10, and eventually become skilful hunters at about age 20.

To undertake a division of labour of this kind, the chimpanzees must have the mental faculty of cooperation. Animals entertaining a solitary lifestyle fail to qualify for cooperation. The chimpanzees must be familiar with their social group and its rules of communication. They must be able to learn distributional rules – norms defining their social ethics – and to adopt trust in the viability of the culture they live in (on the ‘docility’ required, Simon 2005).

Apart from the mental faculty to execute a division of labour, the chimpanzees must also have a particular cognitive faculty to be able to engage in the complex operation of hunting. The inborn faculty becomes manifest in two major cognitive abilities. One is calculating the cost–benefit ratio when making the decision whether or not to engage in a hunt, or when choosing between individual or social hunting. The cognitive ability here refers to the efficiency of an operation given an expected end result.

Chimpanzees may be assumed to employ rationality as described by neoclassical economic theory – though employed at the phylogenetic level of chimpanzees. A model of ‘*Pan oeconomicus*’ will describe the above-mentioned decisions under the assumptions of the perfect rationality a chimpanzee can attain and of omniscience about the environmental conditions relevant for the animal’s decision. It may be expected that, as neoclassical economists move into the area of phylogenetics, hunting models constructed under these assumptions will become available.

The second major cognitive ability required for engaging in organised hunting arises from the fact that an individual is part of a structure. Its operations must be defined in relation to other operations. The operation of an individual cannot be defined in terms of an isolated operation. We enter here a domain of analysis that figures under the label of ‘mereology’ and that deals with problems that are addressed in a ‘science of structure’ (Küppers 2012). Economically, the pivotal point is that the measure of performance is not efficiency any more but, rather, what I call (giving the wholesale term a concise theoretical meaning) ‘efficacy’ (Dopfer 2004). The chimpanzees command not only the ability to make an efficient choice but also the ability to engage in hunting efficaciously, meeting mereological demands.

Efficacy precedes efficiency. A lack of the latter may render a structure welfare-inferior or unfit for survival under selective pressure; but efficacy is a necessary condition for a structure to come about at all.

Let us sum up. Culture in animals is ubiquitous, with its manifestations reaching into provinces such as tool use, tool refinement, specialisation, multi-purpose tools, tool-by-tool production, the division of labour and rule transmission, both horizontally (within a population at any one time) and vertically (preserving culture across generations over time). Further studies by primatologists largely confirm the findings discussed (Cavalli-Sforza 2000; de Waal 2001; Whiten et al. 1999; van Schaik et al. 2003; Sapolsky and Share 2004). The clear evidence of a homology between non-human and human primates in the ability to entertain culture brings us again back to the question:

if monkeys are that smart, why don't they have a culture that in its complexity matches that of humans?

8 Phenotypic expression versus culture

The recognition that, like humans, animals entertain culture is relatively recent. Although reports of nut-cracking capuchins date back in Brazilian folklore as far as the 16th century (Ottoni and Izar 2008), the scientific recognition is due essentially to Jane Goodall's observation of a chimpanzee using a grass stalk to fish termites in the 1960s (Goodall 1967). Until then the conventional doctrine was that humans have culture while animals do not. This view found an apt expression in the distinction between endosomatic and exosomatic tool use proposed by the eminent biophysicist Alfred Lotka in the 1930s. Demonstrating the supposedly unique ability of the human species for culture, Nicholas Georgescu-Roegen, a pioneer of evolutionary economics, adopted this distinction in the 1970s:

Apart from a few insignificant exceptions, all species other than man use only *endosomatic* instruments – as Alfred Lotka proposed to call those instruments (legs, claws, wings, etc.) which belong to the individual organism *by birth*. Man alone came in time, to use a club, which does not belong to him by birth, but which extended his endosomatic arm and increased its power... [M]an's evolution transcended the biological limits to include also (and primarily) the evolution of exosomatic instruments, i.e. of instruments produced by man but not belonging to his body (Georgescu-Roegen 1975: 369).

The assumption underlying this distinction is empirically untenable. The distinction is ingenious, however, and it may render useful services when clarifying the issues of what culture actually is and how cultures of different species differ from each other. Essentially, the term 'endosomatic' is valid for a large portion of non-human species, but not so for all non-human primates and

other animals capable of entertaining culture. Even so, it would hardly be warranted to subsume the culture of these animals under the rubric 'exosomatic', which by definition denotes human culture.

Let us turn first to what distinguishes culture from non-culture in this section, and take up the distinction between the particular kinds of culture non-human and human species entertain in the following.

Animals lacking culture have survived because they all adapted to their environment in their own way. Their biological predisposition enables them to respond to the environment with an invariant behavioural repertoire that is well adapted, and for that reason was selected. Their biological predisposition precludes the acquisition of cultural rules, however, and hence a behavioural response on their basis. The behavioural response is invariant, though possibly manifest in a variety of phenotypic expressions. The range of all responses observed may be expressed as a 'representative' value, for instance by applying a simple S-R model or some variant enriched by operant learning.

The large majority of species have survived by phenotypic adaptation without relying on culture. Many of them have developed a highly sophisticated way of problem solving that in its phenotypic expression resembles, but is not, culture. Interesting questions may arise when the borderline between phenotypic and cultural response becomes fuzzy or difficult to disclose observationally or experimentally. This may include all animals whose extremities are less suitable for tool use compared with those mentioned, such as meerkats, which belong to the mongoose family (Manser et al. 2008).

A hypothesis proposing that the behaviour of a species is genetically conditioned may be considered to be falsified if a case of rule making is observed. For instance, if meerkats are observed learning new behavioural rules for organising foraging or protecting their clan, their behaviour cannot be said to be biologically conditioned. Based on this observation, a theoretical approach that explains the variety and evolution of rules (rather than one describing phenotypic behaviour) may be adopted when formulating hypotheses or devising set-ups for observations or experiments. Success in hypothesis testing may depend on further advances in methods of observation and measurement relating to the evolutionary dynamic of rules.

9 *Endosomatic and exosomatic culture: a hypothesis*

Having run through the gamut of commonalities in culture making between humans and non-human primates, we may gain an understanding of human culture by highlighting the remaining differences between the two sets of cultures.

As a general hypothesis, I propose that non-human animals have the ability to advance what may be called ‘endosomatic culture’. The term ‘endosomatic’ in this connotation means that the animals use culturally generated tools and behaviours in addition to their limbs, but that the expression of culture is entirely dependent on the environmental context. The generation of ‘endosomatic’ cultural rules is, essentially, a mere response to the prevalent external conditions. Unlike humans, they can exercise little, if any, autonomy in generating rules independent from their environment. They have the ability to respond differently to extant environmental conditions, leading to a variety of cultures, but their ability to generate rules remains generally conditional upon the environmental context.

In the following, the endosomatic character of the culture of non-human species is demonstrated on the basis of the observational evidence furnished previously. The examples are intended to underpin the hypothesis that non-human primates and other animals entertain only endosomatic culture. Methodologically, the procedure is, like any inductive inference, confirmatory, but in terms of representing a hypothesis the statements may be falsified on the basis of exposed logical flaws or empirical evidence to the contrary.

Context dependence means that there is a necessary nexus between a behavioural rule and an environmental referent. For instance, in the case of the macaques of Koshima, it was the close proximity between the sweet potatoes and the water of the creek or ocean that provided the conditions for generating the rules of washing.

The hypothesis may be given flesh by providing examples that relate to the phases of the evolutionary trajectory introduced. The process of origination – or invention – may be interpreted as holistic perception proposed by *Gestalt* psychology (Köhler 1925; Wertheimer 1938). The hypothesis of generating a *Gestalt* (holistic feature or pattern) was developed in recognition of observational evidence from problem solving not only by humans but also by chimpanzees (Köhler 1925). As for the macaques in Koshima, the close vicinity of sweet potatoes and water led one of them (a female nicknamed Imo), on a single occasion, to the concept of a functional relationship between them. The cognitive insight derived from pattern

re-cognition of what already existed in the environment. It was not based on an act of cognition that would generate a rule independent of that context. The rule lay dormant in the external context – as a potential to be tapped by a member of the clan.

Similarly, the adoption of the washing rule took place under the same condition of proximity that enabled its origination. The conspecifics staying close in the group were able to communicate the new rule by way of observing, or signalling with sounds, the washing activity.

A further example of the endosomatic expression of culture is the use of stones as tools. The logic of the universal rule trajectory again applies. The invention is based on a process in which the pattern of a stone (size, weight, form, structure) evokes a pattern in the mind of a chimpanzee. By way of introspection, the stone attains tool functions. There is a pattern matching whereby the stone is not only a stone but becomes a template for a rule. The stone is absolutely necessary for the process of matching, and without it a rule cannot come about. At the origin of a rule is not only a monkey's mind but also a stone.

In the same way, the retention of culture is dependent on an external referent. The nexus shows up visibly in a case in which solid objects, such as stones, are involved as substrates of rules. Embodied in solid objects, rules can be conserved over time at a place, fostering cross-generational communication, instruction and learning, which are instrumental for vertical transmission. A washing rule having, as its physical carrier, water cannot be transmitted in this way, requiring the rule to be communicated over generations by means only of the observation of behavior. A nutcracker workshop furnishes archaeological records for millennia; a washing site leaves no traces.

Hunting incorporating a division of labour provides another example of the endosomatic expression of culture. It is considerably more complex than other forms of production, but the condition of a close endosomatic nexus remains. New rules may be hypothesised to originate in a process of trial and error in which some rules of organisation or function are selected over others. Their origination is, again, entirely dependent on the environmental context, such as the kind of wood or the size, height or density of trees. Equally, the prey available in a region may impact on the kind of hunting culture that emerges. For instance, in the region of the Tai National Park, the aforementioned bush pigs are well organised in groups. Assessing the risks, the chimpanzees decided not to embark on that venture, and the hunt for bush pigs, possible though it was, did not become an external context from which hunting rules could evolve.

The impact of the environment on the formation of culture in non-human primates has been the subject of some debate. Generally, differences in culture are recorded to be due to differences in the topographic, climatic and flora and fauna conditions between regions that animals inhabit. Additionally, there are a variety of cultures within a given class of culture that has emerged under the particular environmental conditions of a region (van Schaik et al. 2003; de Waal 2001; Spagnoletti et al. 2012; Ottoni and Izar 2008). A survey of observational findings about chimpanzees in particular regions in Africa concludes that “differences in the behavioural repertoires described have become apparent that suggest there is significant cultural variation” (Whiten et al. 1999: 682).

Although observational evidence is growing, theoretical explanations are still in their infancy. By way of a related example, Eduardo Ottoni and Patrícia Izar concur, noting that “tool use within...capuchin populations seems to be a behavioral tradition that is socially learned and is primarily associated with more terrestrial habits”. This remark prompts a contemplation of the state of the art, with the conclusion that “differences in the ‘tool kits’ between populations remain to be understood” (Ottoni and Izar 2008: 171). Seen from the viewpoint of a trajectory, the proximate cause of variety lies in the genetically determined predisposition of animals to generate, adopt and retain a variety of cultural rules.

The endosomatic position taken precludes any form of environmental determinism – of which universalised phenotypic approaches are prone to fall victim – as there exist a variety of cultural rule responses.

9 Phylogenetic incepts of culture

The endosomatic expression of culture may in some cases be difficult to distinguish from the phenotypic. The phenotypic expression of meerkats has been considered to resemble endosomatic expression, and in the same way the endosomatic expression of chimpanzees or macaques may be assumed to represent phenotypic expression. As with meerkats, the borderline between the two kinds of expressions may be fuzzy.

For example, as we have seen, capuchin monkeys in Brazil remove the leaves and twigs from a branch and make the end thinner in order to increase the efficiency of the stick they so make as a tool for fishing. It is easy to imagine that this tool-making activity pops up spontaneously

without much support from a learning process. The behaviour may be identified as a phenotypic expression rather than as a behaviour based on an acquired rule.

Methodologically, an experimental set-up is conceivable whereby monkeys are confronted with this task under both solitary and group conditions. If the monkeys under the former conditions prepared their stick in the way mentioned, the behaviour could be characterised as phenotypic. The singular phenotypic tool use does not preclude the general use of tools on the basis of rule making, but it does indicate that the borderline is fluid.

Theoretically, this gives rise to some reflections. The recognition that phenotypic and endosomatic expressions are possible bedfellows inspires the proposition of a hypothesis. In its weak form, it states that endogenous culture originates from phenotypic expression; in its strong form, that there is a close correlation between the complexity and frequency of phenotypic events and the probability that endosomatic culture may emerge.

Seizing upon this general hypothesis, the evolutionary dynamic of culture may be seen to unfold in the following phylogenetic sequence:

$$P \rightarrow E_n \rightarrow E_x$$

P stands for a phenotypic expression that has the potential for endosomatic culture, E_n and E_x for endosomatic and exosomatic culture, respectively.

E_n originates from P. Specifically, it originates from phenotypic conditions embodied in P that allow the bringing about of endosomatic culture; this transformation potential does not reside in all P. In its distinct contribution to the origin of culture, it may be said to represent *proto-culture*.

The evolution of culture is a cumulative process. The antecedent is not just a necessary condition for the ensuing stage but is also an integral part of the new structure. Human culture is exosomatic, but it still contains elements of proto-culture concerning basal needs and the associated phenotypic responses, as well as elements determining the endosomatic expression of culture. We may hypothesise that this is true in particular for the early phases of human culture, as is indicated, for instance, from a passage in a piece of work by a precursor:

[T]he first tools were of course discovered rather than invented... Thus the first knife could be found by accident, and I would say made use of in play, in the form of a sharpened stone (Geiger 1878: 37).

The discovery of the potential to use a sharpened stone as a knife is in no way different from the discovery of a stone for nut cracking. Again, we are back to the question: what marks the decisive difference between monkey and human culture?

The difference lies in imagination. Having imagination, humans construct the world, and do not simply react to it. Imagination is the ability to structure the world by assembling distant individual components into a whole without any guidance from a natural object. The construction of the whole precedes its actualisation in the physical world. The process of forming structure takes place on an imaginative time axis independent from any physical nexus between object and animal.

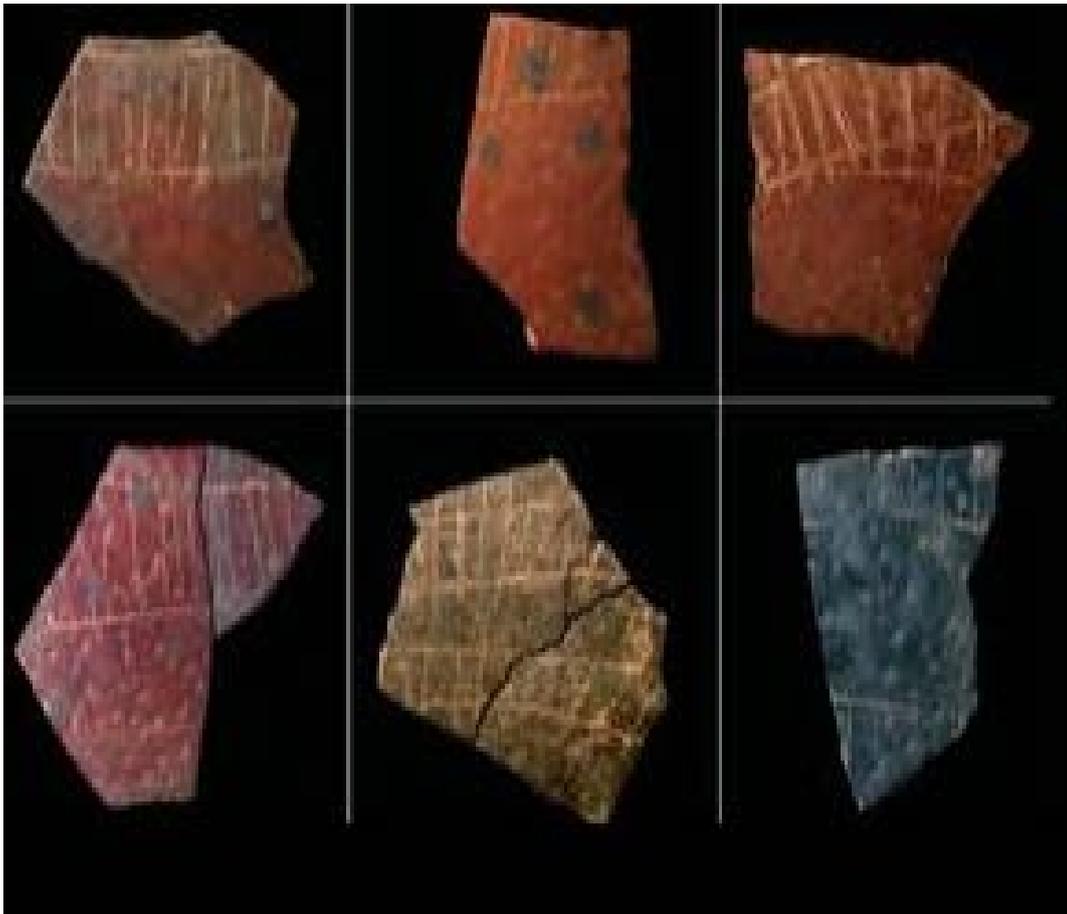
Non-human primates are capable of making temporal decisions, as experiments with chimpanzees and bonobos have demonstrated (Rosati et al. 2007). Given the choice between smaller food rewards in the present and larger food rewards at a later time, they employ a discounting scale when making their choice. *Pan oeconomicus* – akin to HO – is a rational agent, deriving from its decisions maximum utility by computing the flow of discounted food items.

Non-human primates perform very poorly when it comes to imagining structure, however. They are able to organise their hunting, and demonstrate efficacy when piling up three or four boxes to get a banana, but they achieve these feats under the condition that the trees and the boxes are already there. In contrast, James Watt, for instance, could visualise the structure of a steam engine, on the basis of which he assembled the components parts, combining them into what became, after 20 years, an actual steam engine. Many of the results were attributable to trial and error, but there was a sustained intention behind that process, nourished by a vision of a structure.

10 Conclusion: shared imagination makes human culture

Let us have closer a look at the nature of imagination by inquiring into culture in early human phylogeny. Archaeological records from sites in South Africa provide instructive evidence. Researchers have found, in a cage located at Blombos, ornamented shells used as decorative

objects dating back about 77,000 years, and, in a shelter situated at Diepkloof, ostrich eggs with engraved symmetric patterns, possibly serving as water reservoirs, dating back about 60,000 years (Texier et al. 2010; Porraz et al. 2013; Igreja and Porraz 2013). The engraved patterns may serve as instructive examples to highlight the nature of exosomatic rules and the role that imagination has played in their evolution.



Engraved patterns, Diepkloof, South Africa

Image by courtesy of Pierre-Jean Texier

The symmetric structure engraved on an object, such as an ostrich egg, represents a symbol. It is not merely a one-to-one mapping of object and function, as with a chimpanzee's stone and its tool template.

I hypothesise that the *transition from rules as physical templates to rules as symbols* marks the advent of human culture.

A rule as a symbol detached from the physical substrate can be employed repeatedly over time. It has been reported that, in this way, the symbols found on objects may have evolved over thousands of years (Texier et al. 2010). Additionally, the symbol can equally be applied to different materials; not only to a shell, for instance, but also to a stone or to wood. A rule stated as a symbol is independent of its material carrier. The capuchins are able to use a stone for multiple tasks but they are unable to use the rule embodied in that stone for materials other than stone. Although findings from sites of early human history do not seem to be available at present, the deployment of symbolic rules across physical carriers is possible in principle, and we know retrospectively that it shaped the evolution of human culture significantly.

It is revealing to explore the particular semantic content of the symbols used in the artefacts excavated. The structure carved into objects such as ostrich eggs contains a general as well as an individual component. From the perspective of cultural science or anthropology, this may be readily interpreted as an expression of the aesthetics that humans are capable of. Viewed from an economic angle, the ostrich egg is useful because it may serve as a water reservoir. The value of an ornamented ostrich egg in this way feeds from a dual source: aesthetics and utility.

The aesthetic component of an artefact may be interpreted as value that is additional to that derived from its usefulness. The additional value does not accrue from additional quantities of labour devoted to its production but, rather, from the human ability to create art and to derive from a given pattern utility in terms of both aesthetics and practical function. The archaeological findings indicate that, from the very outset, the aesthetic component has played a role in the evolution of human culture.

It may be hypothesised that aesthetic expression became a major driver in the ensuing evolution of consumer goods. Aesthetic rules may generally be a key determinant in the formation of non-basal preferences. They are instrumental in establishing hierarchies and political power relations and find their comprehensive expression in the arts and sciences. There may have been, in effect, a co-evolutionary circuit between practical and aesthetic rules driving the evolution of human culture – a self-perpetuating dynamic inconceivable in monkeys' culture.

Another exosomatic expression of human culture can be inferred from the individualistic (rather than general) component of the patterns on the ostrich eggs. The individuation of the pattern establishes a connection between an artefact and a human being as a person. This connection *ad personam* is not established by physical possession of the artefact but, rather, by the symbol it

carries. Chimpanzees or capuchins may also possess stones or sticks as tools but they exert possession by physical mandate rather than by any claim based on an assigned individual symbol.

A symbol differs from an endosomatic rule by pointing expressly to the possessor of an artefact. In this way, it can be the basis of societal protection by way of assigning property rights. The assignment may be private or collective, coded or uncoded. The point of general significance is that only the exosomatic detachment of a rule from its carrier enables the transition from a social rule of possession to one of property, which is widely considered as shaping the evolutionary course of human culture.

A major driver in human evolution has been the increase of markets, which are defined as the locus of exchange operations. Expanding markets may, indeed, have been the cause of Neolithic innovations rather than their effect (Ofek 2001). Again, however, it is not the exchange activities per se that count for the human distinction but the particular way that humans have been conducting trade. Non-human primates are capable of exchanging artefacts and services, including sex as well (Gomes and Boesch 2009), but their exchange operations are constrained by the sensory rule nexus, which drastically reduces the volume of artefacts they can trade (excluding aesthetical goods), as well as by their dependence on sensory proximity for communication, which effectively constrains their spatial expanse. The scope of exchange operations is further limited in that the domain of exchange is restricted mainly to relatives (Wilson et al. forthcoming).

The distinctive features of human exchange operations may again be highlighted by using the 60,000-year-old ostrich eggs as exemplar. The general component and the individual component both play their part. The individual component provides space for ornamental expression, and in this way heterogeneity may be created – a prerequisite for giving exchange a rationale. The aesthetically valued heterogeneity of objects lies at the origin of human barter trade, the exchange value being defined by differential aesthetic expression.

The general component of ostrich eggs, in turn, was decisive in allowing trade to expand beyond a barter regime, opening up an entirely new dimension. The general component of the structure could serve as a basis for using the ostrich eggs as a general medium of exchange: as money. There is a homology between its general component and the functional attribute of money. The archaeological findings provide an empirical base for revisiting the rationalist reconstructions of the emergence of money advanced by anthropologists and economists

(Menger 1871). It is likely that the ostrich eggs have served various kinds of economic functions – among them that of money. We do not know whether money was actually used 60,000 years ago, but we do know from archaeological evidence that artefacts fulfilling the condition of money existed at that time.

Human culture evolves as new information originates in an individual and is transmitted horizontally and vertically in a population. Chimpanzees, capuchins, macaques and other non-human primates have also been evolving culture in this way. The decisive difference in the transmission of human culture lies in the fact that the communication of rules takes place on the basis of symbols and not on that of physical templates. As a significant consequence, the mechanism of communication must be capable of coding information in symbolic form. It requires symbolic language.

A breakthrough in the biological predisposition of humans was caused by genetic changes enabling humans to use symbolic language (Tomasello 2008; Tomasello et al. 2005). Recent studies have furnished evidence that this process involved rapid genetic changes in the segments of the human genome known as HARs (human accelerated regions), and the *FOXP2* gene, which is assumed to have been responsible for speech and language in humans since they departed from chimpanzees about 5 million years ago (Enard et al. 2002). Notwithstanding many interesting details about the ultimate causes, it can be concluded from the present discussion that language is the decisive factor for sharing imagination.

At the heart of the evolution of human culture lies *shared imagination*, not isolated imagination. Shared imagination is its major proximate cause.

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