Evo-Devo and Culture

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Abstract

What does Evo-devo offer for a better understanding of cultural evolution? Cultural evolutionists with a biological bend typically focus on the relation between genetic evolution and cultural change, a research program referred to as gene-culture coevolution. Development of the human organism is usually left unattended by cultural evolutionists, and so are the processes involved in the production of cultural phenotypes. Moreover, Evo-devo research has yet to have any marked impact on the social sciences. Examining how Evo-devo can contribute to the study of cultural evolution means understanding how cultural evolution and development shape one another. However, it is necessary to first clarify just what sorts of developmental processes we are interested in. There are two albeit not mutually exclusive candidate answers to this question. First, we can be interested in the interactions between cultural evolution and biological development – how does the development of human individuals and the cultural evolutionary process shape one another? Alternatively, we can be interested in

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the interactions between cultural evolution and the generative mechanisms involved in the production of cultural phenotypes. The objective of the present discussion is to address both understandings of the relations between Evo-devo and cultural evolution.

Keywords
Cultural evolution • Evo-devo • Cultural development • Enculturation • Metaplasticity

Introduction

What does Evo-devo offer for a better understanding of cultural evolution? Following Müller (2007), Evo-devo's research agenda can be broadly characterized as the solving of two key problems: how does evolutionary mechanisms generate and modify organismal developmental processes and how does the structure of developmental processes shape back the patterns and processes of species evolution? In order to understand either evolution or development, we need to understand how they shape one another. Analogously, examining how Evo-devo can contribute to the study of cultural evolution means understanding how cultural evolution and development shape one another. However, it is necessary to first clarify just what sorts of developmental processes we are interested in (Mesoudi et al. 2006). There are two albeit not mutually exclusive candidate answers to this question. First, we can be interested in the interactions between cultural evolution and *biological development* – how does the development of human individuals and the cultural evolutionary process shape one another? Alternatively, we can be interested in the interactions between cultural evolution and the *generative mechanisms involved in the production of cultural phenotypes*. We will refer to these two projects as an *Evo-devo of culture* and a *cultural Evo-devo*, respectively.

The objective of the present discussion is to address both understandings of the relations between Evo-devo and cultural evolution. However, the reader should be aware from the onset that there is no such thing today as *an* Evo-devo of culture or *a* cultural Evo-devo. Cultural evolutionists with a biological bend typically focus on the relation between genetic evolution and cultural change, a research program referred to as gene-culture coevolution (Boyd & Richerson 1985). The development of the human organism is usually left unadressed by cultural evolutionists and so are the processes involved in the production of cultural phenotypes (Charbonneau 2015a; Wimsatt 1999). Moreover, Evo-devo research has yet to have any marked impact on the social sciences. However, there is an abundance of existing research that can bridge these gaps, spanning from developmental psychology, ethnography, and/or the neurosciences. Concepts from Evo-devo also promise to offer important insights for the study of cultural processes under a novel, insightful light. So while this entry does not aim at offering a bird's eye-view of an actual research program – there is no such research program to begin with – it will identify key intersections between the Evo-devo framework and its potentially relevant fields of application in the study of cultural evolution.

An Evo-Devo of Culture

Naturalizing Culture

The human capacity to transmit, maintain, and incrementally modify cultural traditions across generations has had major impacts on the survival and natural history of the human species. Think of the many techniques for producing, using, and improving tools and technologies or of the rich variety of belief systems observed in extant and lost civilizations. A great many of human behaviors are neither learned directly from the environment nor are they the product of genetic inheritance. Rather, such human behavioral phenotypes are acquired and maintained from one generation to the next by human individuals learning from one another. In analogy to genetic transmission, which sustains a biological evolutionary process, social learning – the ability to learn from others – sustains a cultural evolutionary process with important impacts on the natural history of our species, a cultural evolutionary process likely intertwined with the biological evolution of our own species (Boyd and Richerson 1985). Accordingly, cultural evolutionists understand a socially learned behavior as a cultural trait when the mental representations (such as beliefs, norms, etc.) or information involved in the production of the behavior has been acquired from others and is widely distributed in a population. Teaching, imitation, apprenticeship, etc., are all key social learning processes, and species devoid of such social learning capabilities will fail to sustain and improve any cultural tradition.

The research program adopted by contemporary cultural evolutionists is a naturalistic one. Adopting a naturalistic approach to the study of human culture means first and foremost understanding social and cultural processes and phenomena in continuity with processes and phenomena of other natural domains, such as cognitive processes, mental states, and biological processes. Accordingly, in addition to the many social sciences specifically devoted to the study of human cultures, such as anthropology, archaeology, and history, the scientific study of culture has now grown into a vast interdisciplinary field involving evolutionary and behavioral biology, the neurosciences, cognitive psychology, and biological anthropology. This does not mean that cultural phenomena are nothing more than psychological or biological processes. Rather, the naturalistic program understands cultural processes as material processes interacting with and partially composed of biological, psychological, and social processes. (Sperber 1996)

It is generally agreed upon that cultural transmission shares many key features with genetic inheritance, features enabling social learning to support an evolutionary process of human traditions. As far as it insures the transmission of behaviors across generations and participates in sustaining a cultural evolutionary process, social learning serves as a nongenetic mechanism of inheritance, one with its very own (nongenetic) channels of transmission (Boyd and Richerson 1985; Jablonka and Lamb 2005). Accordingly, cultural evolutionists typically orient their research towards the transmission patterns of cultural traits and their distribution in human populations. On the basis of the similarities identified between cultural and genetic inheritance, many cultural evolutionists have adopted the modeling tools and strategies of population genetics in order to study the population-level effects of individual episodes of social learning (Boyd and Richerson 1985). However, there are enough differences between genetic and cultural transmission so that models of population genetics cannot be straightforwardly transferred to the study of cultural change. Whereas cultural evolutionists have borrowed modeling methods and assumptions from population genetics, they have spent a great deal of effort specifying how the modeling techniques should be adapted to the idiosyncrasies of cultural transmission and evolution. Central to cultural evolutionary theory then are questions such as who learns what from whom, whether cultural transmission is a high-fidelity replicative process or not (i.e., the rate of cultural "mutation"), and what sorts of biases are involved in the transmission of culture and how these shape the distribution of cultural variation. The disanalogies picked-up by cultural evolutionists thus mainly concern differences in the network and channels of genetic and cultural information transmission. Cultural evolutionary models consequently involve horizontal and oblique transmission – transmission among peers of the same generation and to unrelated individuals of the next generation, respectively – and learning biases, i.e., preferences to learn some behaviors instead of others on the basis of the preferred teachers, of the behavior's outcomes, how frequent the behavior is in the population, etc. Consequently, the differences also justify a nonreductionist approach to cultural evolution as genes and cultures can evolve relatively independently from one another (contra Lumsden and Wilson 1981).

However, there is an important set of disanalogies that cultural evolutionists rarely address, namely, the differences between the structure of genetic inheritance and that of the enculturation process, i.e. the process by which an individual acquires the typical cultural repertoire of its group. Indeed, one important difference between genetic inheritance and the enculturation process concerns the specific moment in the organism's life-cycle and the duration of the acquisition of genetic and cultural information. Simply put, we inherit the whole of ours genes at the moment of our parents' reproduction. In contrast, we inherit our local culture throughout our lifetime and do so in a piecemeal and sequential manner (see Fig. 1). Building up one's repertoire of cultural traits is a life-long process, taking place not before the development of the human organism – and thus, somewhat in isolation of it, as it is with genes – but *during* development. An individual's enculturation is thus sensitive to its biological development. Moreover, a culture's specific enculturation process is structured, and its structure is itself socially transmitted and open to evolutionary change. This seemingly banal fact has important consequences for the evolution and the study of human cultures.

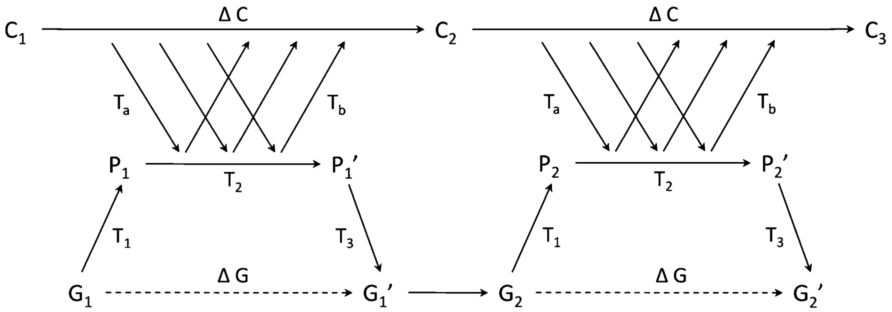

Fig. 1 Whereas organisms typically inherit their genome (G) at the moment of reproduction ($G_x' \rightarrow G_{x+1}$) and carry that same genome throughout their lifetime ($G_x \rightarrow G_x'$), an individual's cultural repertoire is constructed sequentially and in a piecemeal fashion (T_a) throughout its life time (T_2) (Adapted from Durham 1991, p. 186)

How Biological Development Shapes Enculturation

The enculturation process is sensitive to the cognitive and morphological development of the human individual. Perhaps most striking is the sensitivity to morphological development. Cultures adopting a sexual division of labor are nearly ubiquitous. Not only do females and males generally serve different ecological and social roles but more importantly they typically learn and transmit different cultural behaviors (e.g., foraging behaviors, clothing habits, etc.). Such division is based on the recognition by the group that one individual is of a certain gender, a recognition not based on observing the chromosomes individuals possess but on the perceived phenotype of the individual (e.g., recognition of sexual attributes), and often the learned and transmitted behaviors will also depend on the age of the individual (e.g., sexual maturity). The criteria used to distinguish genres vary from one culture to the next.

Cognitive and brain development of the human individual also constrains what can be learned at specific ages. An individual's first language is learned during childhood with little difficulty, whereas second languages learned at a later age will typically require much more cognitive efforts on the part of the learner. Additionally, more complex behaviors and abstract knowledge may only be learned when the proper cognitive capacities and motor skills have developed (Roux and Bril 2005). Just as with morphological development, a community may also adopt different norms for measuring cognitive maturity in order to decide if an individual will be allowed to learn some special skills (Rogoff 2003). Some behaviors and techniques also require a long time to master, whereas genes are all acquired quickly and at the same time. This means that one's developing expertise can interact and possibly be scaffolded with what other knowledge or skill one is learning at the same time.

How a community attests that the learner is ready for learning more about the techniques and who will take over such learning is also variable from one culture to the next (Ruddle and Chesterfield 1977). For instance, this can mean that the network of interactions of an individual within the community may also vary according to the perceived maturity and gender of the developing individual (Rogoff 2003). In Western societies, youngsters will typically learn mostly from their parents but as individuals gain in age, they will enter the schooling system where oblique transmission is the rule. In other societies, youngsters may directly learn mostly from their aunts and uncles as parenting tasks are shared across the kinship and then as they get older join groups of other kids and learn mostly horizontally (e.g., through play).

Human populations vary in what individuals learn, at what age they learn it, and from whom they learn from. The cultural relativity of the enculturation process makes the use of population genetics tools problematic, as population genetics models typically assume a stable life-cycle, one that is generalizable across the species. In contrast, the variability of the structure of the enculturation process implies that models in cultural evolutionary theory may not assume some general cultural life-cycle as there may not be any stable, cross-cultural patterns of enculturation (Wimsatt 1999). Only by integrating the influence of biological development on cultural transmission and its impacts on structuring the enculturation process will cultural evolutionists be capable of articulating a general theory of cultural change.

The varying enculturation patterns are themselves maintained and inherited through social learning, with neither genetic nor environmental factors being capable of accounting alone for the patterns' diversity and stability. For instance, the Greco-Roman education structure strikingly exemplifies the inheritance of the enculturation process, with the Romans intentionally copying (with some adjustments) the education structure of Ancient Greece. In contrast, although they may lack any schooling institutions, traditional societies nevertheless exhibit highly structured, lasting enculturation patterns (Rogoff 2003; Ruddle and Chesterfield 1977). There are other studies in the developmental psychology, ethnography, and comparative pedagogy literatures that deal with the transmission of a culture's typical enculturation process. Unfortunately, there is little if any work on these topics that expressly adopt a cultural evolutionary framework.

Taking seriously the relation between individual development and cultural inheritance implies collecting data about how different cultures vary in the specifics of their enculturation process and examining how these differences enable and constrain the general evolution of cultural traditions. Moreover, this means to pay closer examination of how specific enculturation structures come about and how such structures can undergo evolutionary change. For instance, one key structuring constraint of many cultural traditions resides in the fact that for many cultural phenotypes, to acquire the trait one must already have learned some other cultural traits beforehand. Many complex cultural traits are in fact composed of simpler ones. So, for instance, in order to learn calculus, you already need to have somewhat mastered algebra, which in turns relies on you knowing the basics of arithmetic. These logical constitutive dependencies translate, in terms of the enculturation process, as a strict sequence of learning which must be respected if the enculturation process is to successfully allow the learning and further transmitting of these cultural traits (Wimsatt 1999). Moreover, each step in the sequential acquisition of a complex trait may also depend on the specifics of the individual's cognitive maturity, where the cognitive capacities required to learn and master each trait in the sequence may not develop synchronously. (See Enquist et al. 2011 for a modeling effort of the sequentiality of the enculturation process).

The dependence relationships between cultural traits may have different impacts on the cultural evolutionary process. Wimsatt (1999) argues that enculturation, analogously to the genome, is subject to generative entrenchment. What one learns earlier in its life-cycle is less prone to change as any change risks having deleterious cascading effects on the acquisition of other traits depending on the earlier ones. So if we change the rules of arithmetic, these may not be coherent anymore with algebra or with calculus, leading to the failure of further learning the latter. Thus the stabilization and preservation of arithmetic is necessary for the successful transmission of algebra and calculus. Clarifying exactly at what level the entrenchment of cultural traits are located will prove to be an important part of the study of enculturation. Whereas possessing a language may be a necessary condition for both the invention and learning of arithmetic, acquiring any specific natural language is not. Again, contrary to gene inheritance, where the genome of the organism is typically inherited as a whole during reproduction, enculturation is a piecemeal, culturally variable process. This means that there are likely more chances that "pleiotropic" effects among cultural traits will agglomerate into relatively independent package of cultural traits (e.g.,. learning mathematics vs. learning fishing) rather than being distributed on the overall cultural repertoire of a population. A clear theory of the packaging of cultural traits and of their evolution together remains to be formulated.

How Enculturation Shapes Biological Development

Culture is a special form of phenotypic plasticity. Consider, for instance, the case of Padaung women, known through their touristic name of "giraffe-necked women," as a case of culture interacting with the developmental plasticity of the human organism (Fig. 2). The Padaung tradition of women wearing heavy brass neck-rings has effects spanning on many different levels of the human organism's phenotypic plasticity. The observed depression of shoulder girdle in Padaung women is due to the heavy brass rings they traditionally wear around their neck, thus giving the optical illusion of possessing a longer neck. These morphological changes also result in physiological problems such as increased blood pressure, and the older Padaung further risk to break their necks if the rings were to be removed, making them dependent on an artificial "exoskeleton." Perhaps most striking are the morphological effects, but for the cultural evolutionist, it is the brain's plastic capacity to learn a great variety of behaviors that is central. As a form of phenotypic plasticity, culture can be understood as a mechanism of phenotypic response to the behavioral displays of others. Social learning then is the capacity to reproduce behavioral phenotypes similar to those observed in other members of its population.

Central to culture, then, is the capacity of the human brain to change in response to the local culture. Not only do we learn from one another, but the structural and functional organizations of our brain are greatly influenced by what we learn and the age at which we learn it. For instance, neuroimaging studies have shown cortical

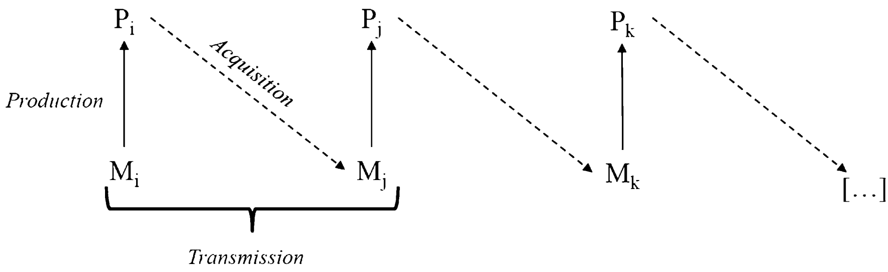

Fig. 2 Social transmission as a multistep process. A demonstrator's mental representation M_x is used to produce (*production*) some cultural phenotype P_x. For a tradition to be sustained, the learner acquires a similar mental representation M_{x+1} by observing the demonstrator's cultural phenotype P_x, and so on and so forth (Adapted from Charbonneau 2015a, p. 531)

reorganization in professional musical skill training which has important impacts on tactile acuity. Moreover, cognitive changes induced by practice are sensitive to the age at which the skill is learned, with early learning leading to better expertise and with an increased ability to learn new tasks (Malafouris 2013). Thus different enculturation regimes may lead to cognitive differences between cultures without involving neither genetic nor noncultural environmental differences. In other words, the brain's plasticity exploited by culture can be altered with by what one learns. This plasticity of brain plasticity is generally referred to by the term "metaplasticity," a term coined to refer to changes in synaptic plasticity induced by synaptic activity (Abraham and Bear 1996). In the context of an Evo-devo of culture, we can understand *cultural metaplasticity* as the capacity of culture to change the social learning processes and the cognitive capacities of the human individual. In other words, the metaplastic capabilities of the human brain makes it a cultural artifact *par excellence* (Mithen and Parsons 2008).

The study of the cultural metaplasticity of the human brain promises important consequences for the study of the relations between cultural evolution and biological development. Culture may not only serve as a behavioral inheritance system exploiting the brain's plasticity for memorization and behavior acquisition. It may also prove to be an important source of cognitive change altogether. In turn, culturally induced cognitive change can lead to cultural changes that would not have been possible otherwise (Malafouris 2009, 2010). For instance, increased tactile acuity in stone tool manufacture may lead individuals not only to learn novel, more demanding techniques of stone tool production, but also to discover novel sophisticated techniques altogether (Roux and Bril 2005). Cognitive change induced by cultural metaplasticity may lead to new possibilities of cultural innovations, with the novel innovations leading to novel cognitive capabilities, and so on and so forth. As individuals' cognitive capacities are partly shaped by culture, these can in turn impact further cultural change, creating an historical process of brain-culture coevolution that does not involve any genetic change. In other words, human cognition may well have, in addition to a phylogeny, a cultural history. Little research has directly addressed the coevolution of cognition and culture from a cultural evolutionary and historical – rather than a phylogenetic – perspective. However, some work in neuroarchaeology is addressing how the material culture has co-developed with cognitive changes in early societies (Malafouris 2009, 2010). Some developmental psychologists have also addressed how social learning capacities are themselves the result of cultural evolution (Heyes 2012).

Cultural Evo-Devo

Cultural traditions are persisting causal chains of mental representations and public displays, such as behaviors (Boyd and Richerson 1985; Sperber 1996). The first link in these chains consists in producing some observable behavior from some mental representation. Whereas we may not directly access the mental representations of others, by effectively producing a learned behavior, an individual's private knowledge becomes publicly available for others to learn from. The second step consists in another individual perceiving the behavior and acquiring from it (or multiple repetitions of it) its very own private mental representation of the behavior. In future instances, the social learner will be able to reproduce the behavioral phenotype, which in turn will make it publicly available for another individual to acquire it, thus sustaining a cultural tradition (Fig. 2).

Cultural evolutionists typically emphasize the acquisition phase of social transmission, studying primarily the maintenance and transformation of the transmitted information. This practice can be illustrated by the use of terms like "cultural variants" or "cultural traits," referring indiscriminately to variant mental representations (e.g., beliefs, preferences, etc.) or to variant cultural phenotypes (e.g., practices, shape of artifacts, etc.), or both. Consequently, the production phase is generally black-boxed and the specific generative processes involved in the production of cultural phenotypes abstracted away. It is at this point that borrowing concepts from the Evo-devo framework promises a better understanding of the interplay between the production of cultural phenotypes and their evolution in what is sometimes referred to as a cultural Evo-devo (see Mesoudi et al. (2006, p. 367)).

There has been little work investigating this avenue mainly because there lacks a clear understanding of just what cultural development – in analogy to biological development – consists of (Mesoudi et al. 2006, p. 367). One possibility is to understand how variation in the socially transmitted mental representations maps onto variation in the cultural phenotypes they produce as a cultural analog to the genotype-phenotype map. Genes do not specify development such that variation of the phenotypes of organisms reduces to variation in their genetic material. Rather, genes and developmental processes interact with one another in complex ways such that the mapping between genotype and phenotype becomes itself a complex affair (Alberch 1991). In analogy, variation in cultural phenotypes would not reduce to variation in mental representations as the specific processes involved in producing the cultural phenotypes may shape the latter's variation in complex ways. A cultural Evo-devo would then consist in studying these complexities.

Most cultural evolutionists are in fact skeptic about using analogies with biological processes. However, perhaps there is no need to find a strong cultural analog to biological development. Indeed, if social learning does in fact serve as a nongenetic inheritance system, the socially transmitted mental representations taking part in cultural traditions can be conceptualized as generative factors participating in the production of behavioral phenotypes, not in analogy to genes, but as *alternative* developmental resources to genetic information. A similar logic would apply to other nongenetic inheritance systems (Jablonka and Lamb 2005). In the context of cultural evolution, we can thus understand the production phase as a form of cultural development, i.e., as the processes involved in the production of cultural phenotypes for inherited developmental resources, here socially acquired mental representations. A cultural Evo-devo, then, would examine how the generative processes involved in the production of cultural phenotypes interact, shape, and are shaped by cultural evolution.

The first step in developing a cultural Evo-devo should be to clarify just what the generative processes are made of. Following Mesoudi and O'Brien (2008), we can understand the structure of the generative processes involved in the production of cultural phenotypes through the concept of a *cultural recipe*. A cultural recipe is a hierarchically organized set of actions and decisions leading to the satisfaction of a specific, intended goal. The hierarchical structure of recipes can be decomposed into subassemblies of actions serving some subgoal that must be satisfied on the road to the intended end-product, i.e., the cultural phenotype. A subgoal consists of a measure of what conditions need to be satisfied and what to do next if the conditions are perceived as being satisfied and what to do when they are not. These subgoals can also be nested as intermediary steps in the realization of some other subgoals, thus generating a potentially complex structure of dependencies between action and decisions assemblies. Ultimately, all subgoals are ruled by a single master goal, that of the final intended end-result of the recipe. The hierarchical structure of recipes is typically depicted as a tree-like structure (see Fig. 3 for an example).

Cultural recipes are themselves transmitted from one generation to the next, and can vary, which confers them the capacity to evolve. Adequately, adopting explanatory concepts and tools from Evo-devo will thus highly depend on whether the structure of cultural recipes can vary in ways similar to the development of an organism from its genetic material and environmental context of development. There have been some suggestions that the production of cultural phenotypes and the evolution of recipes are fit to adapt parts of the conceptual framework from Evo-devo. In the remainder, we will discuss two of these – cultural modularity and that of a cultural genotype-phenotype map – and some of their consequences – such as cultural evolvability and cultural developmental constraints.

Mesoudi and O'Brien (2008) argue that complex recipes, ones possessing many levels of actions and decisions subassemblies, are likely to be decomposable into *cultural modules* given that recipe subassemblies tend to be more functionally integrated with one another than they are with the whole recipe. In other words, similarly to a modular genetic architecture, complex cultural recipes would be nearly decomposable. Moreover, such functionally modular subassemblies will tend to be transmitted as units as they can be learned as whole and relatively independently

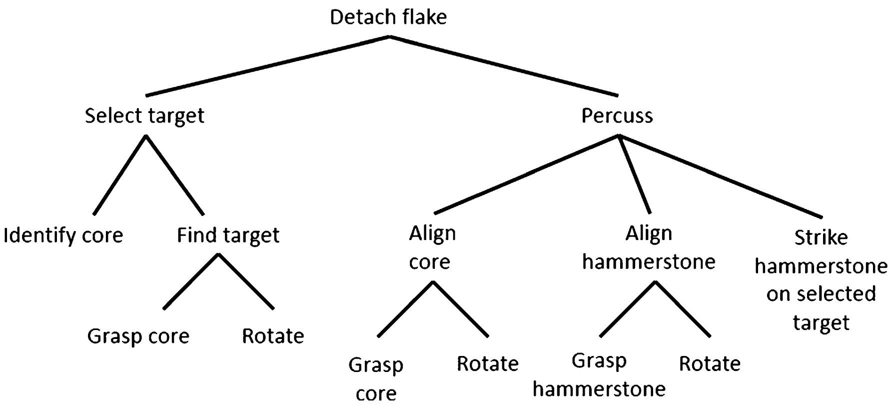

Fig. 3 The hierarchical structure of flake detachment. Early prehistoric stone tools were produced by detaching flakes off a core stone by hitting it with a hammerstone. The flake detachment behavior is composed of two main subbehaviors that of selecting a target on the core and that of percussion. Selecting a target consists in choosing a specific point on a core to hit with the hammerstone. Percussion consists in appropriately positioning the core, grasping the hammerstone, and striking the core on its target platform. Specific actions are represented at the lower end of the tree. Decisions are indicated as nodes (Adapted from Stout 2011, p. 1052)

from one another or from the complex recipes in which they figure. Mesoudi and O'Brien (2008) models also suggest that the more modular cultural recipes are, the higher their chances of being transmitted. Modular recipes thus would have greater evolvability than more holistic (or less-modular) ones, as cultural modules, once learned, can be used in many different recipes (see also Charbonneau (forthcoming)).

Mesoudi and O'Brien (2008) offers a formal treatment of the structure of cultural recipes and do not address the different material and productive constraints involved in the cultural development process (Charbonneau forthcoming). Producing cultural phenotypes is a causal story starting with an individual's mental representations and ending in the public display of a specific cultural phenotype. This means that the production phase depends on cognitive, bodily, and ecological processes that are not necessarily involved in the acquisition phase. The production of cultural phenotypes may thus have its own enabling and constraining effects on social transmission and consequently on the evolution of cultures. The study of the generative mechanisms involved in the production of cultural phenotypes will thus be a complex endeavor, requiring the cultural evolutionist to address multiple mechanisms at different levels. Charbonneau (2015a) identifies four of these levels:

1. The cognitive processes and biases participating in the generation of public displays from mental representations (e.g., decision-making processes, mental imagery, motor control, etc.)
2. The external actions recruited in the production of the public displays (e.g., locomotion, prehension, manipulation, pronunciation, etc.), including the affordances and constraints set by the particular body of the demonstrator (e.g., opposable thumb, flexibility, dexterity, body size, mass, etc.)

3. The specific tools and materials used to produce the public displays (if any)
4. The ecological processes engaged in the production of the public displays (e.g., chemical reactions, percussion effects, sound-wave propagation, etc.)

Charbonneau (2015a) argues that when these generative factors are taken into account, many assumptions typically adopted by cultural evolutionists may prove wrong. Once such assumption consist in the metrics used to assess gradual cultural evolution. Cultural evolutionists typically assume that errors in social transmission and even intentional transformations of cultural traditions tend to produce relatively similar cultural phenotypes. In other words, small changes in the transmitted information will result in small variations in the cultural phenotype, leading to a process of gradual cultural evolution that can be studied mainly at the level of the information being transmitted. However, taking into account both the complex structure of cultural recipes and the material processes involved in the production of cultural phenotypes shows that small modifications in the recipes can lead to large changes in the phenotype. Inversely, small changes in phenotypes may in fact depend on large changes in the structure of the recipes. For instance, Charbonneau (2015a) points out that in order to augment the width of lithic blades from 2.4 cm to 2.6 cm, stone knappers had to pass from a pressure-flaking technique to the use of the lever as only the latter could exert enough pressure to detach the wider blades. Whereas the blades are very similar (they have 0.2 cm of width difference), the underlying techniques and the set of behaviors and artifacts they depend on are radically different.

A closer look at how the productive processes constrain the variation of cultural phenotype may reveal further complicated cases of cultural genotype-phenotype mapping (or mental representation-public display mapping), challenging the typical cultural evolutionist's assumption of an isomorphic mapping. Moreover, investigating such mapping and the structure of cultural variational spaces can reveal which cultural forms of cultural phenotypes are possible and which ones are not (Charbonneau 2015b), suggesting that observed convergence in form in different cultures may be the result not so much of similar adaptations but of generative constraints on the development of cultural phenotypes.

Further work is required to make a more serious case for both an Evo-devo of culture and a cultural Evo-devo. Research in both directions is only at an embryonic stage. However, in the future we can expect further advances on the impact of enculturation and metaplasticity on cultural evolution, and also on issues pertaining to cultural modularity, evolvability, and constraints of cultural development. An important part of such work will consist in addressing what nonevolutionary social sciences already have to say about the cultural process and integrate such work into an evolutionary framework before any useful contribution from Evo-devo can be productively harnessed.

Cross-References

► Evo-Devo and Cognitive Science

► Evo-Devo of Language and Cognition
► Evo-Devo of Social Behavior
► Modularity in Evo-Devo

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