

9 Scaffolding on Core Cognition

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This chapter argues that cultural evolution is scaffolded not just on material culture and social organization but also on innate cognitive abilities. In view of the diversity and richness of cultural productions, one might be tempted to overlook the role of evolved cognitive abilities, whose (biological) functions are restricted to domains of the environment in which they have evolved. How, for instance, could our evolved abilities for cognizing magnitudes be used for dealing with contemporary mathematical knowledge? I argue that even in these cases where beliefs and behavior go far beyond the range of the evolved function of cognitive abilities, these abilities might nonetheless act as scaffolds. In order to make my point, I rephrase the work of cultural epidemiologists as showing that culture evolves via multiple scaffolds, made of both transmitted artifacts and public representations, and core cognition—a set of nonperceptual innate cognitive abilities. I develop this point by considering the case of conceptual change in science and mathematics.

Cultural Cumulation When Innateness Matters

Cumulative Cultural Evolution

What is the cognitive basis put to work in cumulative cultural evolution? Richerson and Boyd's (2005) answer is that humans have a capacity for culture: we are able to transmit information from one individual to another with a fidelity which, if supplemented by dispositions to gather information from the most prestigious or from the majority, lead to a production and natural selection of cultural items. One does not need to have a precise understanding of the psychological mechanisms at work in cultural transmission, but one can assume that humans are equipped with some psychological features that do enable the *reproduction* of cultural items with sufficient fidelity so that selection can operate. The reasoning seem to be as follow: (1) cumulative cultural evolution is an empirical fact easily documented by history; (2) cumulative cultural evolution can only result from a process of blind variation and selective retention since one needs to disregard teleological accounts; (3) for selective retention to occur there must be a mechanism that replicate,

with a sufficient degree of fidelity, the selected items—cultural items in our case. Psychology, of course, should have a crucial role in settling the question about the existence of a cognitive mechanism that replicates (Sperber, 2006). However, something else should also play an important role in the debate: it is the adequate description of cumulative cultural evolution, which is the phenomenon that these psychological theories of cultural transmission are supposed to explain.

Advocates of accounts of cultural evolution by natural selection such as Boyd and Richerson have argued that one need not have detailed knowledge of the psychological mechanisms of transmission for developing an account of cultural evolution: Darwinism was a good scientific theory even before we understood the mechanisms underlying heredity. But theorists of biological evolution have recently emphasized the importance of understanding how phenotypical traits develop: the field of “evo–devo” has shown the limits of an evolutionary theory that would black-box the processes producing phenotypes (Pigliucci and Müller 2010). In other words, understanding why some phenotype is distributed in a population requires one to not just apply population genetics—as if there was a straightforward one-to-one mapping from genotypes to phenotypes—but to integrate studies in developmental biology. This point is also of great importance in the study of cultural evolution. The point has been made most forcefully by Wimsatt and Griesemer (2007), who developed an evo–devo account of cultural evolution. Likewise, “cultural epidemiologists” (Sperber, Atran, Boyer, Hirschfeld, and others; see e.g., Sperber 1996) have long been arguing that detailed analyses of the causal chains that lead to the production and reproduction of cultural items are necessary for understanding cultural evolution. Analyzing the processes that produce cultural items leads, according to Sperber (1996), to a different understanding of the causes of cultural stability: it is not so much obtained via a sufficiently faithful reproduction, but because the constructive biases will sometimes tend to gather produced cultural items around a “cultural attractor.” In evo–devo terms, the idea is that, in spite of the differences in what is being transmitted (genes or cultural items), the developmental processes will be such that produced items will tend to be similar to an archetypical item.

An evo–devo approach to cultural evolution provides a framework and a rationale for integrating psychology and studies of cultural phenomena. It can also specify differently what should be meant by cumulative cultural evolution. The cumulative, in cumulative evolution, is intuitively described as the fact that culture is built upon the discoveries, beliefs, or practices of previous other members of the community. The term is also meant to grasp the fact that culture gets more and more complex and that culturally acquired knowledge has progressively empowered us. It is difficult to have an idea of cumulative evolution that grasps our intuitions that “complex” cultures have garnered achievements from their past. There are many dead ends to avoid: there is a risk of falling in the trap of the much decried ideas of cultural evolution of nineteenth-century anthropology (a teleological evolution toward civilization—here Victorian civilization), and there is a risk in

implicitly relying on a naive idea of progress (e.g., the one upon which philosophers of science broke their teeth in the first half of the twentieth century).

The cumulative aspect of cultural evolution has been used by proponents of dual inheritance theory to argue that transmission of cultural knowledge, rather than mere reaction of populations to the specifics of their habitats, was the factor that could account for cultural phenomena (Richerson and Boyd 2005). An image that easily comes to mind is one of piling up: during cultural evolution, humans pile up new ideas, traditions, and know-how. There is certainly some truth in this image. However, I would argue that Wimsatt and Griesemer's terms of "scaffolding" and "generative entrenchment" better grasp a central aspect of cumulative cultural evolution (Wimsatt and Griesemer 2007). The notion of "generative entrenchment" suggests that faithful transmission is not a necessary characteristic of cumulative cultural evolution. Rather, old ideas are used in the generation of new ideas, and this is why they are stabilized. Old ideas are stabilized in time especially when they have become the basis of other widespread ideas and practices—they become entrenched. Although cumulative cultural evolution connotes having more and more ideas that are stable and distributed in a community, cumulative evolution is also meant to refer to phenomena such as transformations of ideas and behaviors. Numerous new ideas emerge from old ones and would not have evolved if the old ideas had not existed first, whether these old ideas remain cultural or not. Furthermore, ideas and behavior can become more and more complex, in the sense that they are interdependent for their existence and stability.

When scaffolding is multiple and hierarchical, then there is a cumulative cultural phenomenon. In the last section, I will appeal to Susan Carey's work to assert that multiple hierarchical scaffolding on evolved cognitive abilities can lead to conceptual change. Conceptual change, as the acquisition of new concepts, is probably the most drastic case of progress in knowledge acquisition. Even if it does not straightforwardly fall into our idea of cultural cumulative evolution, it is what eventually needs to be accounted for. Admittedly, there are other aspects of cultural evolution that are referred to by the adjective "cumulative." For instance, the distribution of cognitive labor enables people to become more knowledgeable in specific domains and ignorant in other domains that are covered by others. Economic exchange permits people to remain ignorant in certain domains and invest their cognitive resources in others. As a consequence, the group as a whole is more knowledgeable than when all members of the group know the same basic survival knowledge.

Unconstrained Cultural Evolution?

If one considers cultural evolution as a piling-up process, then one needs both a stable basis and sufficient variability for new cultural items to be produced and adopted. One can further be led to believe that properties of the human mind are what enable such results. A stable basis can be ensured by a transmission process that is sufficiently faithful, and

the adoption of new cultural items can be enabled by a mind that is receptive to novelty because it is sufficiently “plastic.” The old ideas stay the same thanks to faithful cultural transmission; the new ideas are adopted thanks to human abilities to learn all kinds of new things. This account of cumulative cultural evolution and its underlying processes is an “ideal type” on the scale of possible accounts. Memetics and dual inheritance theory are not far from this ideal type. These theories call on sufficiently faithful imitation as a mechanism of transmission. In view of the diversity of cultural items to be copied, the fidelity requirement is also a requirement for a certain cognitive plasticity. The rationale is that cultural evolution takes us far from our initial capacities to act upon the world and dramatically changes our behavioral repertoire (e.g., browsing the web rather than gathering edibles). With cultural evolution, humans managed to free themselves from their initial obvious limitations. But then the bounds to our innate cognitive endowment must not be so tight since we managed so easily to free ourselves from them.

Criticisms of these approaches have emphasized that humans do not faithfully copy what is transmitted to them or that they do so only in rare circumstances (Sperber 2000; Atran 2001). According to Sperber’s account of cultural stability, transformations always occur at each transmission step of a transmission chain. One can obtain cultural stability when the transformations are biased toward a given type of item. This is a statistical property of transformations: they are such that they produce cultural items that are more likely to resemble more a given type of item—called a cultural attractor—than did their predecessors (Sperber 1996; Claidière and Sperber 2007). Cultural stability results from the presence of cognitive biases that act on the content of what is being transmitted. The causal explanation of such statistical properties can often be found in the specific properties of the human mind: humans process the input in such a way that the output will look more like the cultural attractor. Cultural stability comes as a consequence of the mark left by the constructive processes involved in the chains of transmission. Some of these constructive processes can be found in the environment and social institutions, others—and these are the one of interest in this chapter—in the human brain. Wimsatt and Griesemer (2007) have developed a relatively similar account of cultural stability: it is to be accounted for by the development of “cultural developmental systems” rather than by straightforward copying. However, while cultural epidemiologists have emphasized the role of psychological properties in stabilizing the production of cultural items, Wimsatt and Griesemer have emphasized the role of environmental factors—described as scaffolds for development. For reasons that will become apparent before the end of this chapter, I will talk of mental scaffolds for describing psychological factors of stability, combining insights from cultural epidemiologists (especially Sperber) and from an evo–devo account of cultural evolution (especially Wimsatt and Griesemer). I will first review some relevant theories about innate cognitive abilities that should make a difference for cultural transmission. I will then argue that these innate abilities have a causal role not just for explaining cultural stability of what Cosmides and Tooby called “evoked culture”—the mere effect of local aspects of

the environment on cognition and behavior—but that they are implicated in the production of those cultural phenomena that seem to take us away from our initial limitations.

The notion of innateness has been widely debated, especially in the evo–devo literature, and I will make a relatively naive use of the notion in this chapter. Samuels (2002) has advocated a notion of innateness for psychology: a cognitive ability is innate whose development does not require the acquisition of information. This characterization is adequate for the goals I have. Since I will rely on Wimsatt’s ideas of evolution, it is worth noting that he advocates analyzing in terms of generative entrenchment what is generally thought in terms of innateness (e.g., Wimsatt 1986). There is however a time scale difference between generative entrenchments of biologically evolved cognitive abilities and generative entrenchments of culturally acquired skills. The cognitive abilities that I characterize as innate have a biological evolutionary history rather than a cultural evolutionary history. This, I think, is sufficient to warrant the use of “innate” that I make in this chapter.

Core Cognition: A Rich Innate Endowment that Matters

No one would deny that aspects of human biology frame culture: the shape and size of hands constraint material culture, such as which tools there are and what their shapes are; the range of sounds we can hear constrain the kind of music that is played; the number of things we can remember at a time constrains schooling traditions. The constraints of anatomical properties are pretty straightforward, but the constraints of psychological properties are much more difficult to describe and their effects on culture are more difficult to pin down. Nonetheless, these properties are likely to have a role. But what are these properties that are likely to frame culture in nontrivial ways? I will now point toward recent developments in cognitive psychology that indeed describe innate cognitive abilities. I will then argue that these abilities enable *and* scaffold cultural cumulation.

A lot of work in the last forty years or so has demonstrated that humans are endowed with domain-specific conceptual abilities. Domain-specific conceptual abilities are those that enable making inferences in some specific domain. For instance, the ability to ascribe intentions to others (mind-reading abilities) enables us to predict others’ future actions. This contrasts with sensory abilities, which are presumed to analyze the input but do not support inferences about the world. This also contrasts with domain general abilities, which support processes for any kind of input. Domain-specific abilities will process only specified types of input: face-like stimuli for face recognition, autonomous movement for agency core cognition, quantities for naive arithmetic, and so forth. Domain-specific conceptual abilities embody knowledge about their domain. There is strong evidence that some of these domain-specific conceptual abilities are innate. These are called core cognitive abilities by Carey (2009).

In *The Origin of Concepts* (2009) Carey gathers much of the empirical evidence showing that there are distinct innate domain-specific capacities meant to deal with material objects, quantities, and intentional agents. The mental capacities involved include core object

cognition, analogue magnitude number representations, multiple object tracking/parallel individuation, and agency core cognition. These abilities have systems of representations that carry innate knowledge and ground specific inferences. For instance: representations of material objects sustain inferences about what will happen when two objects bump into each other (they won't go through one another); analogue magnitude representations sustain inferences made on the relative sizes of two distinct sets (young babies know which one is bigger); representations of goal-oriented action sustain inferences about rational behavior and underlying intentions (babies will expect certain behaviors but not others). These core cognitive abilities have peculiarities that issue recognizable patterns of behavior. Carey calls these patterns signatures and uses them as means to reveal the cognitive processes at work in a task.

The innateness claims are based on the idea that what is innate need not result from some learning process. In order to test the inferences made by small infants (with limited behavioral repertoire) developmental psychologists have analyzed the looking patterns of babies who watch controlled sequences of stimuli. There are “violation-of-expectation” studies, habituation studies, anticipatory looking, and so forth. These types of data are complemented by studies in cross-cultural psychology, pinning down inferences that are made across cultures, by studies in comparative psychology, pointing out that a given ability is shared with some nonhuman animals, and by neuroscientific studies.

Core Cognition as a Factor of Cultural Stability and Diversity

What role do these psychological factors play in cultural evolution? Core cognitive abilities determine or constrain some cognitive causal chains that happen within the heads of individuals.¹ Some cognitive causal chains, however, extend across individuals, as when one perceives an object, then testifies as to what she has seen to someone else, who then processes what is communicated to him. The cognitive causal chain extends, in that case, over two individuals. It involves perception, core object cognition, verbal production, and, in the second subject, verbal understanding and object cognition. In between the first and second subject, a public representation—the uttered words—takes part in the cognitive causal chain. Social cognitive causal chains paradigmatically result from communication, but all sorts of social interactions produce social cognitive causal chains: deriving information from observing others' behaviors, using the tools they produced, and participating in economic exchanges are all types of social interactions that produce social cognitive causal chains. Some social cognitive causal chains extend across many individuals, in time and space, and cause the distribution of similar representations and/or behaviors in a community and its habitat. They constitute cultural phenomena; Sperber (2001) calls them cultural cognitive causal chains (or CCCCs for short). Straightforward examples of CCCCs include chains of tale telling (archetypically from parents to children), passing on technical knowledge and know-how through students' attending to teachers' actions (with or without explicit demonstration), and rituals such as church attendance every Sunday.

In this framework, explaining cultural phenomena amounts to answering why some social cognitive causal chains recur again and again and thus distribute cultural items in a community and its habitat. Cultural phenomena, indeed, are constituted by the resulting distribution of mental representations or public productions (which, if sufficiently distributed, qualify as cultural items). Core cognition is likely to constrain CCCCs because (1) the causal chains go through individuals' minds and (2) the input to the mind issued from social interactions is likely processed and enriched via core cognitive abilities. Enrichment of the cultural input occurs, for instance, when characters of religious beliefs are endowed with intentions and beliefs (Boyer 2001), when the classifications of the fauna is learned with its "essentialistic" characteristics (Atran 1990), when masks are perceived as expressive faces (Sperber and Hirschfeld 2004), when natural languages are learned on the basis of limited evidence, and so on. Cultural input underdetermines cultural ideas, but they trigger inferences that lead to the production of cultural ideas. The triggered inferences are implemented by previously existing mental inferential mechanisms that are shared by the members of a community. Core cognitive abilities are the first candidates for enrichment since they are shared by members of any community, and empirical studies such as Boyer's, Atran's, or Astuti's show that they do actually play a role.

When a cultural input satisfies a core cognitive ability's input condition, then it triggers it and produces inferences and new representations. Masks, for instance, are cultural productions that trigger face-recognition abilities (Sperber and Hirschfeld 2004). Triggering cognitive mechanisms increase the number of inferences that can be made and thus make the triggering input more relevant. In other words, relevance in a cultural context can be achieved by inputs that trigger preexisting cognitive mechanisms. Relevance in any culture can therefore be achieved by triggering the inferential mechanisms of core cognition. Many cultural items are well distributed in human populations and across time partly *because* they trigger evolved mental mechanisms in ways that effortlessly produce numerous inferences. Boyer (2001), in particular, shows that religious beliefs trigger evolved cognitive mechanisms (e.g., the notion of a god triggers our naive psychology) and include some counterintuitive information (e.g., a god that can see everything) that make the beliefs attention grabbing.

In addition to increasing relevance, core cognitive abilities are mechanisms that stabilize cultural items because, in spite of relative dissimilarities in the input (there very rarely is a faithful copying process), the inferences that core cognition enable lead to the production of similar ideas. Feed similar cognitive devices with *relatively similar* inputs, and you should obtain outputs that gather around a "cultural attractor." The reason why stabilization sometimes occurs is not so much because there is faithful copying by members of a community; it is rather because the constructive processes construct similar ideas or lead people to have similar behavior. The constructive processes can be thought of as developmental processes that are relatively robust in the face of the small variations that

necessarily occur in the causal chains. These cognitive robust developmental processes are what Boyer called “cognitive tracks” (Boyer, 1998).

Cognitive tracks are social cognitive causal chains that are more likely to occur than others, given a range of input. The existence of cognitive tracks lead to the emergence of cultural phenomena, and cognitive tracks exist mainly because all humans are endowed with similar, evolved, inferential mechanisms that together constitute core cognition. Thus, one can say that core cognition often scaffolds cognitive tracks, and that cognitive tracks are cultural developmental systems, that reproduce cultural items. This formulation enables linking the theoretical framework of cultural epidemiologists with the work of Wimsatt, Griesemer, and, more generally, the evo–devo literature (the field that shows the relevance of evolution for developmental biology and the reverse). Rather than cognitive tracks or repeated social cognitive causal chains, Wimsatt and Griesemer talk of “cultural developmental systems” that are “reproductive” because components perform generative scaffolding function for the production of cultural items.

Wimsatt, Griesemer, and Caporael have especially emphasized the role of environmental scaffolding for learning and culture while cultural epidemiologists have especially emphasized the role of mental scaffolds. However, whether one talks of cultural causal cognitive causal chains and cultural tracks, or of cultural developmental systems, one is calling for the studies of the stabilizing factors, be they environmental or mental. In other words, one is calling for the studies of the environmental or mental scaffolds that enable the developmental processes to be sufficiently stable. Can core cognitive abilities play the role of scaffold according to the use of the notion by Wimsatt and Griesemer? Certainly, since they have a generative role in the production of cultural items. Their idea of scaffold, meant to characterize things and events that play a crucial role in development, applies to properties of the human mind for cultural developmental systems. Cognitive tracks are scaffolded cultural developmental systems, and it is an empirical matter to pin down where the scaffolds lie. Cultural epidemiologists have provided arguments and empirical evidence that suggest that they greatly lie in core cognition.

Cultural Cumulation Results from Multiple Scaffolds

It is often assumed that cultural diversity is based on psychological diversity: evolutionary theories of the beginning of the twentieth century presupposed differences in the mentalities of the people of different cultures (e.g., Lévy-Bruhl 1910), and contemporary anthropological relativist theories assume that the mind is so malleable that enculturation accounts for all those psychological properties that ground cultural thinking and behaving. Cultural diversity could be seen as providing an argument against ascribing a role to the universal psychological properties of the mind in framing cultures. If people were bound to think in the same ways, the argument goes, how come they have such different beliefs and types of behaviors across cultures? Cultural epidemiologists and evolutionary psychologists have

argued that cultural diversity can be based on properties of the mind that are shared cross-culturally. One question remains: if one can account for cultural diversity, taking into consideration innateness, can we also account for cultural cumulation? The account so far has mainly considered the impact of innate abilities in the emergence of cultural phenomena. However, one aspect of cultural evolution is that we seem to move away from a naive understanding of the world. This is a further challenge for cultural epidemiologists since cumulative cultural evolution is primarily thought of as bringing us away from the thoughts and behavior we would normally have in, say, the environment of the Pleistocene. Nonetheless, core cognition remains instrumental, I will argue, in generating those thoughts and behavior that constitute “cumulated” culture. More precisely, core cognition scaffolds culture: it makes accessible new competencies that are generative of cultural phenomena. Core cognition is part of most, if not all, cultural developmental systems.

Beyond the Evoked/Transmitted Culture Dichotomy

Tooby and Cosmides (1992) argue that cultural diversity can arise because the universal mental mechanisms are put to work on different inputs from different environments: people living in the same location are likely to experience similar circumstances, which evoke similar responses, while people living in different locations experience different circumstances that evoke different responses. One obvious example is that people living in hot places tend to be lightly clothed while people living in cold places wear clothes that keep them from the cold. The variation of environmental conditions provides local similarities and general diversity of responses, thus leading to cultural phenomena. Cosmides and Tooby call “evoked cultures” the cultural responses to diverse environments, that is, the local “similarities [in thoughts and behaviors] triggered by local circumstances” (Cosmides and Tooby 1992, 210). By contrast, “the process whereby the thought and behavior of some individuals (usually from the preceding generation) is passed on to other individuals, thereby causing the present pattern” (209) gives rise to transmitted culture.²

Cultural transmission and environmental evocation are two ways in which cultural diversity can be brought about. Although Cosmides and Tooby do think evocation and transmission operate together in the production of cultures, their work, and the work of evolutionary psychologists and sociobiologists in general, has largely focused on evoked culture. In order to emphasize the role of evolved cognitive abilities in shaping cultures, they have attempted to explain many cultural phenomena as evoked culture rather than the result of social transmission. The topics investigated in this way include kinship, mating behavior, and parental investment—where Hamilton and Trivers’s work has provided much insight for evolutionary theorizing (see, e.g., Salmon and Shackelford 2007). In order to reestablish the balance, Richerson and Boyd (2005) emphasize the role of transmitted culture. They provide several cases of cultural phenomena that cannot be accounted for by evocation alone. Technical knowledge, for instance, is cultural knowledge that it is not reinvented by each member of the culture on each generation. Rather, it is transmitted

among the members of the culture. It “improves” through Darwinian processes and can become quite complex. Boyd and Richerson have advocated dual inheritance theory, according to which both genes and cultural variants are transmitted across generations through two different channels. Yet, as I already mentioned, the evolved cognitive mechanisms that they consider as psychological foundations of culture are mainly enabling cultural transmission (Richerson and Boyd 2005, chapter 4) and selecting cultural variants (transmission biases: Richerson and Boyd 2005, 69–77).

The evoked/transmitted dichotomy can result in some misleading oversimplification: by trying to show the importance of the role of either evocation or transmission, one tends to ignore the constructive processes that involve, at the same time, the following:

1. Input from the environment, which is often the results of both nature and human action.
2. The properties of the mind, which are most often the results of both genetic constraints and the cognitive past of the individual.

The properties of the mind determine how the input will be processed to produce some further, mental or public, representations; these processes are, of course, the result of cognitive development, which itself results from both genetic constraints and individual history. The input can be communicated, or it can result from other kinds of social interactions and human actions, or it can be “free” of human action. The evoked/transmitted dichotomy leads one to ignore the richness of these processes, where the production of the cultural item can be entrenched on multiple aspects, social or not, of the environment and in multiple ways. In particular, on the one hand, studies of evoked culture emphasize that cultural items are the output of some mental cognitive processes; they tend to ignore how this output contributes to framing the environment in which neighboring agents, present and future, live. On the other hand, studies of transmitted culture in memetics and dual inheritance theory tend to downplay the role of the constructive processes that produce the output.

There is another, related, misleading consequence of the evoked/transmitted dichotomy: while cultural diversity can be explained by both “evocation” and cultural transmission, only the latter process appears to be able to produce a cumulative culture. Evoked culture is described as being unable to account for cultural cumulation because it does not factor in the achievements of past individuals as shaping future cultures. With evoked culture, we don’t get to “stand on the shoulders of giants”; we are bound to reinvent the wheel. This is, essentially, how Richerson and Boyd argue for emphasizing the role of cultural transmission (2005). Cultural cumulation is thus left to rely on cultural transmission only, which is then pictured as based on imitative skills only, and cognitive plasticity. Against this view, I will argue that cultural cumulation can result from, to use the terms of the above debate, “evocation” at work on things that are transmitted, or, in more adequate words, from cognitive tracks that are based on multiple scaffolds.³

Multiple Scaffolds

Going beyond an evoked/transmitted dichotomy enables the analyst to study the multiple factors that lead to the production of a cultural item: not just *what* is transmitted, not just the way information in the environment is being processed by core cognitive abilities, but *how* transmitted information, together with other information in the environment, is being processed by developed human cognitive abilities and, possibly, other causal factors. Eventually, the analyst comes to describe social cognitive causal chains: chains of causes and effects that crucially involve representation and cognition and that span several individuals. In the set of inputs that trigger cognitive devices in the social cognitive causal chains, some of them might come from others' behavior (social input) and some of these inputs might also include a communicative intention, some might come from aspects of the environment that have not been touched by human activity, and some by aspects of the environment that are human made, such as dwellings. When the social cognitive causal chains are sufficiently repeated for constituting a social phenomenon, then some scaffolds must be at work that guide cognition along the repeated chain.

Wimsatt and Griesemer (2007) describe several scaffolds that exist out of the mind: artifacts, infrastructure, and others' behavior. The painter's scaffold is itself an artifact that scaffolds the painter's painting practices. Artifacts often play a crucial role in cognitive development: think of the weight of pupils' bags when they go to school! They are stuffed with books, color pens, a compass, a speed square, notebooks, glue, pencils... Such artifacts participate in enculturation and thus scaffold culture. One of Wimsatt and Griesemer's examples of infrastructure scaffolding culture is drawn from the history of the Sears House Company, which had been successful in the first half of the twentieth century selling kit houses in the United States. Dwelling in Sears houses is clearly a cultural phenomenon. Wimsatt and Griesemer describe how this phenomenon was scaffolded by the roads and rails, which made possible the transportation of the kit houses, and by the post, which, among other things, distributed Sears catalogs. Others' behavior as scaffolds to learning, and in particular enculturation, is straightforwardly observed in Western cultures, where teaching is strongly institutionalized (teachers' actions are meant to scaffold learning). Wimsatt and Griesemer also describe Cambridge University's evaluation system as a case of scaffolding of cultural phenomenon. This system institutionalized, in the nineteenth century, written exams as a mode of evaluation in mathematics. This, in turn, led to the institutionalization of the system of tutorials. These constrained the cognitive development of a part of the population—primarily the Cantabs doing the Mathematical Tripos—which then took on specific cognitive habits and produced cultural phenomena (especially teaching practices).

Nonmental scaffolds for cultural phenomena are important because learning often relies on such scaffolds, and because material culture should not be underappreciated, but also because the cognitive mechanisms that process and distribute cultural items are often out

of the head. Theorists of distributed cognition have shown that the production of some representations (public or mental) is often done through a process that spans several people and cognitive artifacts systematically organized. A seminal example concerns the way we add large numbers, using pen and paper and relying on the numbers we write to perform the computations. Ed Hutchins (1995) provided several analyses of distributed cognitive systems: the pilot in his cockpit relies on the display of the many buttons and switches to memorize procedures; the navigator in his ship relies on many tools, but also on other people who have specified tasks in the production of representations for locating the ship, and the institutionalized organization of labor. More generally, the availability of technical devices and other artifacts often enables, in our cultural species, specific actions and thoughts. The analyses of Jack Goody (1977), Merlin Donald (1991), and many others on the role of writing nicely illustrate this point.

Wimsatt and Griesemer have focused on nonmental scaffolds, but they also mention, *en passant*, the acquired taste for Sears houses (2007, 271): a disposition to decide to buy a Sears house that is realized in the minds of individuals. In the first section, I have argued that properties of the human mind should also be thought of as scaffolding cultural phenomena. Material culture, social organizations and institutions, core cognitive abilities, and skills and knowledge issued from enculturation: all can function as scaffolds for cultural phenomena. They shape cognitive tracks that span minds and the environment and that lead to the reproduction of social cognitive causal chains. I have now briefly acknowledged the role of nonmental scaffolds, but my point in this chapter is to expand upon the idea that mental properties act as scaffolds for cultural stability and changes.⁴ In the next subsection, I further ponder enculturation as a means to go beyond core cognition. Then I will show that enculturation itself is scaffolded on core cognition. In the final section, I will insist on the pervasive and highly generative role of core cognition as scaffold.

Mental Scaffolds

Environment definitively scaffolds cultural evolution and learning, but mental capacities can also fruitfully be thought of as scaffolds. In the first section, I have pointed out the role of core cognition in participating in the construction of representations that become widely distributed in a population and its habitat. This participation is “scaffolding for cultural stability” because it is a contribution to the development of cultural systems that reproduce. For instance, face recognition scaffolds the cultural stability of mask production: producers of masks rely on their face-recognition capacities when working, and other members of the community “demand” masks because these tap their face-recognition capacities.

The constructive cognitive processes at work in the production of cultural phenomena can themselves have developed as a result of enculturation. I refer here to the fact that human cognitive abilities are not just the result of biological evolution, but also of cognitive development during each individual’s lifetime. Cognitive development can be largely

canalized by genes, but it is codetermined by the environment, including the cultural environment. Natural language is the most striking case in which both evolved learning abilities (which are species specific) and cultural input are combined to give an obviously cultural capacity of speaking a given natural language with the plethora of ensuing cultural phenomena. But evolved capacities are put to work in the cognitive development of many other capacities constituting culture. Atran (1990), for instance, has argued that we are endowed with an evolved capacity for thinking about animal species, which constrains cultural classifications of the animal realm (scientific Darwinism being a notable exception). Know-how is also acquired by relying on some innate representational system: Marchand (2010) argues that carpentry, which is taught in great part via demonstration, is acquired by cognizing and parsing demonstrated actions directly via motor-control representations.

As learning and acculturation happen, the properties of the mind change, and so does the potential for further learning. People are not only learning new things, they are also learning to learn, as scientists in education like to say. Enculturation refers to more psychological phenomena than the incremental acquisition of transmitted, cultural beliefs and values. Enculturation and learning in general have consequences for the generative mechanisms sustaining cultural evolution. Cultural beliefs and values scaffold new knowledge and skills. While Boyer has emphasized the role of core cognition (intuitive ontology) as forming the cognitive mechanisms that shape cognitive tracks, there is no reason why no other cognitive mechanisms—learned ones—play a role in stabilizing culture, *as long as these mechanisms are sufficiently distributed* in a population. Indeed, the more general question of cultural epidemiology is about which cognitive mechanisms are already in place in a given community and thus likely to shape cognitive tracks. In other words, the relevant cognitive mechanisms cannot be idiosyncratic—because these have no effect at the population level—but they need not be universal. For shaping cognitive tracks, it is sufficient that the cognitive mechanisms be shared by a fair proportion of the people in a community. This is exactly what happens with enculturation: well-distributed ideas in the community have consequences not just on what people believe, but, to some extent, on how people think. Strauss and Quinn (1997), for instance, describe the mental models for marriage that are widely shared in the United States, and they show how these learned models further determine the life choices that are taken by couples. Max Weber's study on the Protestant ethic provides another example of a cognitive track shaped by enculturation: it argues that religious ideas about afterlife can have effects on personality formation, and then on economic behavior. From a distribution of theological ideas, there evolves a distribution of ideas about oneself (e.g., as being chosen), which inform the cognitive mechanisms at work in making economic decisions. We therefore have a sociocognitive developmental process that eventually forms the basis for a cognitive track, out of which a cultural phenomenon arises. Capitalism, Weber might say, is generatively entrenched in Protestant theology.

Note that, with such psychological scaffolds, the bases of the scaffold may change with cognitive development. My own bet, however, is that cognitive plasticity does not go as far as to permit drastic changes of the bases of the scaffolding and that the inferential power of core cognitive abilities play a pervasive role in cultural evolution.

Core Cognition and Conceptual Change

Beyond Core Cognition via Enculturation

Conceptual change is probably the most radical way to go beyond core cognition. It is one striking achievement of cultural evolution. In the history and philosophy of science, conceptual change is the event that shows that the history of science cannot be understood as a mere process of adding up more and more true beliefs about the world. The history of science is not a cumulative process in the naive sense of adding more and more true beliefs, even though science is probably the most striking illustration of cultural cumulation, in the sense that it explores spaces that could not be explored without long and complex social transmission chains. An account of the psychological foundations of conceptual change has recently been given by Carey (2009).

Quinian Bootstrapping: Multiple Mental Scaffolds

In her book *The Origin of Concepts*, Carey gives detailed descriptions of conceptual changes occurring during childhood. She points out the consequences of conceptual changes as they occur in the mind, and she attempts to describe the psychological processes that lead to learning new concepts. Her case studies are the concepts of natural numbers, rational numbers, and the differentiated concepts of density and weight, and heat and temperature, which she claims all result from conceptual change. She bases her claims on the comparison of these conceptual systems with their predecessors: they are, she explains, incommensurable. These latter acquired concepts articulate intuitive theories that transcend core cognition. For instance, infants are born with core cognitive abilities for perceiving and thinking with magnitudes and with tracking up to five entities, which enable dealing with numerosity efficiently. However, the latter acquired concepts of natural numbers go beyond the knowledge embodied in these core capacities. For instance, the knowledge that every number has one and only one successor is acquired together with the concept of natural numbers. Carey thus shows that conceptual change actually occurs during cognitive development: one cannot think of all acquired knowledge as mere enrichment.

Her further contribution to the study of conceptual change is a description of the developmental processes that lead to learning new concepts. She terms these processes “Quinian bootstrapping.” Describing psychological processes leading to conceptual change is a huge challenge. Fodor asserted that we cannot learn what we cannot conceptualize, and he

concluded that we cannot learn new concepts. Fodor, however, restricted learning processes to types of hypothesis formation and testing. Quinian bootstrapping must therefore be more than hypothesis testing.

Two essential components enter Quinian bootstrapping: some preexisting knowledge structures and a new system of public symbols (linguistic terms, graphs, and so on). New concepts are acquired when the explicit symbols of the system acquire meanings that cannot be expressed in the preexisting knowledge structure. For instance, learning natural numbers necessitates relying on both analogue magnitude number representations and parallel individuation mentioned above. Surpassing the expressive power of core cognition, however, requires making use of constructed explicit symbol systems whose content does not, initially, need to be fully understood. In the case of natural numbers, the explicit symbol system is the number list, which children learn by heart and put into practice even though they initially do not understand, for instance, that the number of the last object counted is the number of items in the set. Learning events in Quinian bootstrapping involves providing meaning to the mental representations that correspond to the explicit representations (e.g., the string of terms “one, two, three, four, five, ...”). They get their meaning from their interrelation with other symbols (e.g., three is the successor of two), from modeling processes such as making analogies, and from “inductive leaps” (e.g., the number that comes in the list after n is the successor of n and is equal to $n + 1$).

One can characterize this process of recruiting the inferential power of several core cognitive abilities as building intuitive theories on multiple scaffolds. It is the multiplicity of the scaffolds that makes it generative of ideas (and technologies) that are so radically new. An important aspect of Quinian bootstrapping is that it is entrenched not just on multiple cognitive abilities but also on external symbol systems. External symbol systems are human artifacts. They need to be produced and transmitted. The core cognitive abilities, by contrast, are already there.

Quinian bootstrapping is a developmental process that relies both on core cognition and on transmission with relatively long and intense training. Carey insists that learning new concepts is a difficult thing to achieve relative to enriching our knowledge basis. It requires enculturation with scaffolds on public symbols structure (e.g., the list of natural numbers) and guided learning about permissible inferences and procedures (e.g., when learning to count with natural numbers, one needs to learn the cardinal principle, which states that when counting items of a set, the ordinal of the last counted item is the cardinal of the set). However, with all the help of the sociocultural environment, the inferential power of core cognition is still necessary for scaffolding intuitive theories.

Quinian Bootstrapping and Cultural Evolution

How do such developmental processes come into play at the cultural level? If Quinian bootstrapping is indeed the process that leads children to know such key cultural concepts as natural numbers, then it might indeed play an important role. Yet, Carey’s examples of

Quinian bootstrapping are few and are limited to Western schooling. Is Quinian bootstrapping restricted to a few instances in Western culture? And if so, why is it the case since the cognitive mechanisms put to work in this cognitive developmental process are shared by all humans? Providing cases studies showing that Quinian bootstrapping indeed occurs elsewhere than in contemporary cultures with specific schooling traditions, and/or specifying the conditions that foster this developmental process, is a worthwhile enterprise that has, to my knowledge, not yet been fully undertaken. One can however notice that numerals, with their many diverse notations and systems, have been cultural items for at least 5,000 years and appeared in different cultures in different forms. Moreover, the point that I make in this chapter holds independently of whether conceptual change is common or not: even in cases where acquired knowledge departs so much from core cognition that it relies on a different conceptual basis, core cognition is still important.

Another question concerning the importance of conceptual change at the cultural level is whether it replaces, rather than just complements, the role of core cognition with new inferential mechanisms in cultural evolution. What happens to core cognitive abilities once conceptual change has occurred? One possibility is to see developmental processes, including Quinian bootstrapping, as enabling a departure from core cognition. Core cognition, in this case, would have a role mainly as the initial stage in which to mold enculturated individuals. Culture itself would then be constrained by core cognition only insofar as it is a necessary starting point for enculturation. Evidence, however, shows that this is not the case: conceptual changes create new intuitive theories but do not replace core cognitive abilities. Intuitive theories continue piggybacking on core cognition. This is made apparent with the mental magnitudes representational system in numerically literate adults. For instance, these adults are quicker to say which of two numbers is bigger when the difference between the two is bigger. This is evidence that numbers, even when expressed with some cultural systems, come to be represented with mental magnitudes representations. Moreover, intuitive theories are not necessarily put to work when not necessary: most of the time, we evaluate quantities intuitively and begin to count only when necessary.

The previous subsection argued that conceptual change is a developmental process that scaffolds on core cognition. The above two paragraphs argued that, even when conceptual change has occurred, core cognition is likely to have a pervasive role in human cognition and, for that reason, in CCCs. I now want to conclude this chapter with an illustration of how core cognition can influence conceptual change as it occurs during cultural evolution.

I submit that the historical advent of a mathematical or scientific theory may sometimes be viewed as new ways, culturally implemented, of recruiting specific cognitive abilities and intuitions, including core cognitive abilities. When the intuitions and abilities are the results of biological evolution, they are normally put to work to solve the problems they have evolved to solve. The cultural context, however, is made such that these abilities and intuitions are also put to work for solving culturally framed or constructed problems.

The hypothesis that I defend is that historical changes in conceptual frameworks have, *ceteris paribus*, a better chance to be taken on by a community if the changes exploit at relatively low cost the inferential power of existing abilities or skills (whether acquired or innate). In other words, concepts and theories are more likely to be culturally successful if they are scaffolded on widely shared inferential mechanisms. Shared inferential mechanisms provide inferential power, and thus relevance, to the cultural concepts and their associated theories. The general claim that concepts and theories are more valuable and successful if they have higher inferential power has been made in philosophy of science. For instance, it is reflected in the literature on scientific simplicity and unity (e.g., Kitcher 1981). Simplicity can be understood as the fact that many inferences can be made on the basis of little *new* theoretical information; unity can be understood as the fact that inferences can be made in several domains on the basis of one set of concepts and theoretical claims, while it did not use to be the case. To this point, I add the following: inferential power is obtained when core cognitive abilities are recruited. They are recruited when the cultural input is framed in such a way that it triggers the inferential mechanisms of core cognition. In a way, scientific and mathematical theories are likely to be successful when they trigger inferential mechanisms of core cognition for the same reasons that make masks, which trigger face-recognition mental mechanisms, culturally successful.

Providing historical analyses of scientific historical events showing the role of core cognition in the cultural evolutionary process is not easy: this is because scientific and mathematical theories are scaffolded on multiple and hierarchically organized scaffolds. Unearthing the usually strongly entrenched core cognition is difficult. This attempt has been made for the history of many mathematical notions by Lakoff and Nunez (2000), but they unfortunately do not recognize the richness of the initial endowment that is core cognition and attempt to ground most mathematical cognition on motor cognition. I have pointed out the likely role of the object tracking system (part of core cognition) in a detailed attempt to understand why Newtonian concepts in the calculus have been more successful in early France than Leibnizian concepts (Heintz 2007b). Newtonian concepts call on evanescent quantities as resulting from a process while Leibnizian concepts call on infinitesimals as mathematical entities. The problem with the latter concepts is that they lead to a contradiction of our intuition that, if one adds an entity to an existing set of entities, then the resulting set is bound to be larger. This intuition is produced by the object tracking system, a core cognitive ability (infants tracking objects are surprised if adding an object to a small set of objects does not increase the cardinality of the set; they expect the set to increase). According to Carey, the object tracking system is recruited for learning the successor notion that is at the heart of natural numbers. With the Leibnizian concept of infinitesimal, it is contradicted: we obtain equations of the type $x + dx = x$. These types of equations were widely debated in the early eighteenth century in France (Mancosu 1989). In the end, the concepts used by mathematicians, the way they came to think of the calculus, were more akin to the Newtonian concept of “evanescent quantity.” This

concept formation is highly relevant to cultural evolution since the Newtonian concept is closer to the notion of “limit,” which will, in the nineteenth century only, provide “rigorous” formal grounds for the calculus.

The history of cultural phenomena is constrained by what abilities and cognitive skills people are endowed with. Cultural items tapping into the cognitive abilities of people, including those abilities whose properties to a large extent result from the biological evolution of the human cognitive apparatus, have better chances to be reproduced or repeated. Mathematical concepts are cultural items, and they are likely to be more popular among mathematicians if they tap into some human cognitive abilities, thus triggering rich inferential processes.

Conclusion

I have argued that understanding the multiple and historically evolving scaffolds that eventually form the basis of cognitive tracks is a key to understanding how cultural evolution can go beyond core cognition and beyond Cosmides and Tooby’s evoked culture. This characterization of cumulative cultural evolution does not require sufficiently faithful cultural transmission as Richerson and Boyd (2005) would have it. It suggests that cognitive plasticity and domain general cognitive skills might not be the crucial elements enabling cumulative cultural evolution. On the contrary, cumulative cultural evolution is made possible via multiple and hierarchical scaffolding. Rich scaffolding, in turn, is made possible because humans have a rich set of domain-specific cognitive abilities to start with, that is, a rich core cognition. I have not raised the question related to how existing inferential mechanisms become scaffolds for cognitive development and cultural evolution, but we can speculate that metarepresentational abilities, model-based reasoning and analogical thinking, and language are likely to be involved.

The notion of scaffold was most nicely developed and illustrated by Wimsatt and Griesemer (2007), on which the analysis of this chapter is ... scaffolded. But I have also emphasized that scaffold need not be restricted, as Wimsatt and Griesemer initially suggest, to artifacts, infrastructure, and agents. The concept of scaffolding can nicely and fruitfully be applied to mental skills and abilities, including core cognition. Doing so sheds light on the cognitive basis of cumulative cultural evolution, including conceptual change.

Notes

1. We can describe psychological phenomena in terms of cognitive causal chains as a result of the cognitive revolution that took place in the 1960s: it is possible to describe mental events in terms of their content and semantic relationship while at the same time assume that they have material implementations and are causally related.
2. Tooby and Cosmides rather talk of evoked versus epidemiological culture, in order to emphasize that the primary causal process need not be located in the individuals from whom the representations are derived.

Epidemiological culture is, for Tooby and Cosmides, very much the result of the processes described by Sperber's epidemiology of representation. However, even though Tooby and Cosmides specify that there are constructive processes in the reproduction of cultural items, the distinction makes better sense in terms of causal factors: either from the environment in evoked culture or from social interaction in epidemiological culture—which is therefore better called “transmitted culture.” I will argue that, in the framework of cultural epidemiology (Sperber 1996), the distinction is misleading.

3. Wimsatt and Griesemer (2007, 249) formulate a similar point when they advocate a non-Weismannian view of cultural evolution, which considers the conjoint causes of artifacts and actors' behavior in the coreproduction of practices.

4. In fact, institutions can act as scaffold, but they can also be analyzed as specific CCCCs (Heintz 2007a) and therefore can themselves be scaffolded on core cognition.

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