# Technological scaffoldings for the evolution of culture and cognition



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**Introduction**. Models of cultural evolution have often been the result of two mutually reinforcing lines of thought. On the one hand there was the 19th century idea that evolution gives us the most general and fundamental model of how change can accommodate both contingency and regularities, while on the other hand there was the institutional longing, among the social scientists, for some legitimating foundation that would link their explanations to laws of nature (of universal scope), thus, grounding the objectivity of the social sciences. The assumption that evolutionary (Darwinian) biology is grounded in such laws leads naturally to the view that the scientific status of the study of culture has to established itself by modeling cultural patterns as ultimately adaptative outcomes of natural selection, which in turn subject cultural actors to *the same (or similar) universal laws as any other objects*.

This train of thought set us in a path that has serious problems. The longing for generality is certainly related to the search for intelligibility of human history, but models of cultural evolution, that attempt "to mimic, for no reason beyond the desire to appear scientific, a theory from another domain… are too rigid in structure to be even plausible" (Fracchia and Lewontin 1999, 78). Indeed, if the explanation of cultural change and stability has to be in terms of "the reductionist model in which individual actors have more cultural offspring by virtue of their persuasiveness or power or the appeal of their ideas.…" (Fracchia and Lewontin 1999, 74). I would have to agree.

In this paper I want to suggest a way of thinking of models of cultural evolution that do not share such assumptions, and thus do not confront such problems. I want to suggest that models of cultural evolution can be understood as models of cognitive processes embodied in the evolution of artifacts. Once we abandon the idea that "hard science" is grounded in laws of universal scope, and thus abandon the idea that scientific explanations have to be grounded on big theoretical structures that systematize such laws, *models of cultural evolution can* *be seen as modeling the technologies of cognition that scaffold both the stability of culture and the sources of cultural innovation*. In this way, models of cultural evolution can contribute as much to our understanding of human cognition as to our understanding of human history. But to understand the claim I am putting forward we need to fill in the empirical and philosophical settings and discuss some terminology.

2. **From laws to mechanisms**. If the world is governed by general laws of nature of universal scope, through our experience we are lead to identify such laws, and then we can think, as logical positivists like Hempel thought, that the aim of science is the discovery of such universal laws on the basis of which we generate explanations for phenomena. But the problem is that in order for our experience to support the belief on such laws, we have to assume that the world is sufficiently homogeneous, that those generalizations covering our experiments or observations may be extrapolated to cases or contexts beyond our experiments or observations. Nowadays there are well known arguments against such an assumption. Cartwright and Giere have given arguments purporting to show that in physics the assumption that explanations rely ultimately on fundamental laws is questionable (Cartwright 1983; Giere 1999). Wimsatt and others have pointed to the importance of mechanisms in the actual explanations developed by scientists (Wimsatt 1994).[1] However, we cannot simply talk as if the explanatory role of,

say, the mechanism of natural selection is there to be, as it were, gazed at. The mechanism in order for it to play its explanatory role has to be situated in an ontological framework in which development, organization and environment play a role in the individuation of the mechanism. The tendency in models of cultural evolution is to forget that the explanatory role of mechanisms requires giving an account of the ontological context in which the mechanism can be individuated and attributed a causal role. Versions of "universal Darwinism" fall in this trap.

On top of these general philosophical arguments there are also specific problems with individuating some "mechanism of natural selection" that is both robust enough and flexible enough that it can support the extrapolation of evolutionary models from one type of phenomena or process to another. Terkel for example suggests that social learning plays a role in niche construction in rats, and to that extent social learning plays a role in evolution (Terkel 1996; Heyes and Galef 1996).

**3. From Culture as Ideas to Culture as Shared Practices**. Let us review Dawkins model based on the concept of meme in order to see the sort of problems we want to focus on. Dawkins basic idea is that the unit of natural selection is whatever has the capacity to replicate and the following conditions are satisfied for the process of replication: those copies have some influence on its own capacity for replication, the copies are not perfect copies, and the copying process is not perfect, that is, there are errors in the copying process (Dawkins 1976, Dennett 1995). From this perspective genetic selection is only a special case of a more general kind of selection that should explain all sorts of changes. Culture can be explained as the result of a process of selection on units of culture, called *memes*, characterized as units of information located in the brain that are transmitted by imitation.

One obvious objection to such an approach is that memes have too little fidelity to support an evolutionary explanation. This is a well-known objection that has been formulated many times in different ways (Dawkins 1976; Aunger 2000; Blackmore 1999). In the preface to Blackmore (1999) Dawkins provides the following response: memetic replication has to do with the copying of instructions, not to mere copying. That is, focusing on memes is fixing on the instructional structures of culture. But this requires some explanation for what Dawkins means by "instructions". To start with, this approach seems to require severing whatever relation there can be between the psychological mechanisms underlying the production of memes and the evolution of culture. In other words, Dawkins assumes that we can understand culture without understanding its supporting cognitive-social scaffolding. Dawkins, and in general the selectionist models of culture, claim that such scaffolding can be bracketed in an evolutionary model of culture because instructions are *self-normalizing*- that is, social actors copy the instruction process by interpreting intent as well as imitating action. But unless we have an independent way of supporting the view that an account of the evolution of culture can be severed from its supporting cognitive-social scaffolding, that threatens to be circular.

The idea of the self-normalizating role of the instructions is exemplified by Dawkins using the following thought experiment. A child is taught how to make a boat out of paper following the Origami technique. When the child has mastered the technique he is asked to show it to a second child, and so on. Dawkins thinks that even if it is possible that a child forgets one of the steps of the technique another child might realize what is missing and end up with a boat with the original design. Dawkins conclude that the paper phenotype is not transmitted and thus the phenotypic defects are not transmitted, only a set of self-normalizing instructions is transmitted. But that does not seem quite right. The instructions do not seem to be "self-normalizing". The normalization involves for example knowledge of the material involved, the sort of modifications you are allowed with a piece of paper, and knowledge of the sort of things you aim to construct. Is the child reconstructing the right boat after learning the technique with a defective example knowledgeable that he is constructing a (specific kind of) boat? Should we expect the same sort of renormalization of the design if we give the child a piece of plastic?

Consider a different example. If for example we teach A how to make a cake, and then A teaches B how to make the cake, and so on, even in one of the persons in this chain forgets a step, putting enough sugar, for example, it should be not hard for a person that has learned the recipe (and knows about cakes) with this missing step, to realize that the sugar is missing and that one should add more sugar to have a good cake. In this case it is very clear that there are social standards as to what is the right amount of sugar in a cake that allow the instructions to be corrected. But it is clear that attributing the normalization to the instructions, here, misplaces the locus of action by misplacing the source of the norm. Rather, it seems, it is the cultural context that includes the education of our taste what normalize the instructions.

Dawkins would like to say that this is not the sort of instructions he has in mind, but prima facie, at least, making a cake is as paradigmatic example of culture as is the Origami technique. It seems that for Dawkins the notion of "instruction" that matters is supported by the analogy with neo-Darwinian biology and in particular the assumption that there is a universal selection mechanism that works on this abstraction. But this imposes a view of culture that is too restrictive. Of course models must have a normative role in ordering the sort of phenomena we want to understand, but the success of population biology in achieving the synthesis between genetics and natural selection can be attributed to a mechanism that fails to support the required distinction.

If we focus in the history of science instead of a thought experiment a more fundamental problem comes to the fore. The history of science suggests an important sense in which self normalization (and thus stability of practices) should not be assumed to be a matter of transmitting instructions.[2] Think of Euclidean Geometry. Netz has very convincingly shown that the "shaping of deduction" (taking place through the development of Euclidean Geometry) requires understanding the role played by two different tools, mathematical language and diagrams (Netz 1999). Diagrams exploit (visual) cognitive resources. These resources are combined into a method that generates the artifact that we identify as Euclidean geometry. *The artifact is such that it generates products that have a convincing generality. They produce norms and standards (theorems in this case).*

Netz claims that Euclidean geometry achieves its generality through the way in which different basic parts which are the result of the combination of linguistic and diagrammatic resources constitute a "tool box". *Such tool boxes constitute the core of a common practice, a core of shared norms and standards, supporting the stability of its products*. Shared beliefs, or shared (formalized) institutions would not explain the stability of the results. Different beliefs are congruent with the same affordances and implementation of the tool box, as to what is a particular cultural product and in particular how the affordances implemented by the tool box are to be interpreted. But if shared beliefs do not explain what we do it is not feasible to model the stability of practices as the results of the transmission of instructions.

One could think that in this particular case no shared beliefs and formal institutions were required since the stability follows from the inherent generality of the mathematics that we grasp a priori. This is a possible answer for a mathematician that has been educated after Hilbert. But this suggestion would be of no help, since for Greek mathematicians (see chapter 6 of Netz 1999) mathematical proofs were about **specific objects in specific diagrams**. Euclidean geometry (for the Greeks at least) was more like Origami or molecular biology than what Hilbert made of Euclidean Geometry centuries later.

The question remains. How such practices endorse generality and support stability of the relevant practices? Netz claims that the key is repetability. The proof may be repeated for **similar** (homoios) cases, and that is what constitutes the ground for asserting the generality. Ultimately then, Netz's suggestion is to explain *the stability of cultural features not by reference to the stability of instructions (understood as some sort of code) but instead as resting on locally applied formulas supporting (material) constructs that generate successful products (in accordance to values implicit in the practices in question.* The stability in question is thus associated with the (apparently paradoxically) capacity to support innovation. Of course, if we are committed to usual accounts of cognition that take cognition to mediate between perceptions and plans of action then what has been said above has no implication for cognition and its evolution. And more to the point, it is then very hard to integrate into a model of the evolution of culture the role played by lineages of social norms (including those rooted in technology). As Birkhard and Terveen point out, since the grounding of symbols is not as important for understanding cognition as a characterization of the nature of interactions grounding the representations, the traditional view of representations cannot be made part of an evolutionary account of cognition: *"encodings" can only transform, "encode or recode representations that already exist*" (Birkhad and Terveen 1995, 21). Netz example suggests that practices play a crucial role in the characterizations of the interactions that matter, from a cognitive and cultural perspective, for understanding stability and change.

If we make the evolution of culture depend upon modeling representations that have the capacity to reproduce as a central part of an evolutionary account of culture requires developing a bottom-up architecture for cognition, in order to contextualize its objects appropriately (Martínez 2006). One well-known source of such sorts of accounts of representation comes from behavioral robotics. For Brooks the advancement of robotics required cognition to be modeled by constraints that are the product of an evolution of technology, which is analogous to the way biological evolution imposes constraints to human cognition (Brooks 1991). But Brooks' point can be turned around: *in order to model the evolution of human cognition we have to modeled cognition as grounded in representations that are not (mere or only) mental encodings*. In the interactionist view proposed by Brooks, Birkhardt and Terveen (among others) representations are constructed through development, learning of skills and abilities that constitute capacities for reproducing representations carried out through a paradigmatic activity, the sort of activity that is conformed by a practice. Since such activity involves artifacts I talk of artifact-representations- representations having a history that matters to explain its normative and causal role in the evolution of culture and cognition.

The above account suggests that science, just like other cultural achievements, must be understood in terms of shared practices that constitute socially distributed capacities that may either lead to stabilization, innovation, or extinction. This is in accord with a tendency in the social sciences to focus in the importance of social networks as frameworks from which definitions and measures are derived. Social networks are, for example, seen as the embodiment of social intelligence that has implications for group structure, and in particular for practices in highly complex societies.[3]

The objection that science is somehow different in kind from other social practices cannot be countenanced on the scientific basis: it persists because of the longstanding tradition of thinking of cognition as something that only takes place inside the head. Once we begin to cognition as distributed in our practices, a feedback relationship with external footing in our social technological world, we can't consider science to be an exception to this rule: it is, rather, one of the great examples of this rule. Science as a social practice offers us many well documented examples of how distributed cognition works. Contrary to many other social practices-such as making art, herding, etc, science has an impressive documented history; and furthermore, the rate of "mutation" of its practices makes of (particularly some) scientific practices as natural a model for the study of cultural evolution, as drosophilae fruit flies for studying evolution. There is yet another sort of argument that points to the importance of shared practices to model cultural evolution.

**4.The Evolution of the Human Mind piggy backing on Culture**. Clive Gamble has argued that the usual periodization for the change from hominin brains to human minds is highly questionable. The usual view, takes the same sort of linear model of human evolution that Darwin sometimes fell into and places the emergence of the human mind relatively recently and suddenly, around 60,000 years ago, when art, architecture and writing suddenly appear (Gamble 2010). This is considered to be evidence for the emergence of the sort of symbol-based cognition that distinguishes the human mind. This usual answer is of course in accordance with the received view about implausibility of the thesis of continuity that did guided most thinking about cultural evolution in the 20$^{th}$ century. The problem is that the evidence points to the fact that increases in brain size during about 500,000 years are not matched by comparable changes in technology. This fact suggests that symbol processing might not be the right sort of process to focus on to understand the evolutionary process that allow us to frame appropriately the question of when and how the hominid brain became the human mind.

Gamble points to an answer that implicitly promotes the sort of continuity that I am arguing for. He starts with the social brain hypothesis, according to which our social lives drove the enlargement of our brains and considers that the encephalization event 600,000 years ago has two major consequences. One is that a strong relationship exists between neocortex size and group size among primates (Aiello and Dunbar 1993). And two, as Aiello and Wheeler (1995) pointed out, such an increase in brain size was correlated with a decreasing gut. This leads to increased use of animal protein and cooking with fire. Encephalization thus becomes a selective pressure on the development of ways in which individuals can live in larger groups (not necessarily consisting of an integrated group of individuals but some sort of pattern of dispersed local groups drawn from the wider community). This leads to a form of sociality (that seems to be characteristic of all hominins) in which several grouping levels are loosely connected in time and space but potentially accessible as resources for a common aim. Aiello and Dunbar (1993) propose that larger communities would have required new ways to facilitate interaction. Language would be one solution to the extent that it permits hominins to use the environment as a scaffolding for the interaction of agents. Cooking, says Gamble, becomes part of the cognitive architecture of hominins since it coupled brain size with an external manipulation of the environment.

But there is a more basic kind of scaffolding that would be required for extended cognition to shape the evolutionary process of the human mind (in accordance to the continuity thesis). Increases in community size due to encephalization puts pressure on ways in which more complex sort of integration of local groups can be achieved. Language by itself cannot achieve this sort of integration. The use of language as part of an extended architecture of cognition should be seen as part or component of the evolution of stable kinds of interaction that are flexible enough to allow for learning from experience over the lifespan and through generations. This requires the development of an ability to manipulate information about social relationships, an ability that is constrained by specific cognitive abilities, but also *requires the capacity to exploit the enduring properties of material objects by turning them into material culture that is transmitted through generations and allows the complexification of social networks.*

Thus, as the example of archaeology and anthropology show, as well as the more chronicled examples of science, material culture becomes embodied in norms and practices and plays a crucial role in the individualization diversification of practices, and thus is a crucial support for its capacity to innovate, and be transmitted through generations. Shared understanding about the possibilities and appropriateness of practices is a crucial way in which an individual belongs to a community. But how are stability and innovation related to each other, and in particular how is this stability and innovation embodied in practices?

**5**. **The problem of stability from the standpoint of practices**. Dawkins provides a well known example of how the relation of mutual support between cognition and culture are minimized in his model of cultural evolution, thus allowing for the issue of stability (of relevant interactive organizations) to be reduced to a problem about the stability of transmission of information. We have suggested that we should start thinking of the question as a question about how mechanisms of production of items of a kind (mechanisms of re production) and (relatively specific) mechanisms promoting stability, all of them embodied in practices, interact to produce cultural phenomena that can function as scaffoldings for spreading and innovating cultural products that centrally involve enculturation or enskillment in material culture, as well as specific forms of cognitive embodiment (that should be seen as kinds of evolvability).[4] In particular, this framework should account for innovation and its relation to transmission and stability in a non ad hoc way. Dawkins universalist bent leads him, and many others, to assume that there is a mechanism, imitation, that explains both the spread and stability of culture. We have already mentioned that there is important experimental work that shows that this is a questionable assumption. The long and inconclusive discussion about the definition of imitation should end with the conclusion that there is not one notion of imitation that plays the central role usually ascribed to it in models of cultural evolution. Further more, as Cladière and Sperber (2010) argue convincingly, even if one accepts that imitation is more faithful than other forms of social learning this is not enough for imitation to explain cultural stability.

Sperber has made clear that in order to account for the stability of cultural items (and in particular the normalizing role of instructions) we have to take in consideration the ability to attribute aims and intentions (Sperber 2000). I fully agree. But it is important to realize that the attribution of intentions requires sharing standards and individuating situations, and this is a role for practices. Unless standards are in place, and memory and expectations are shared, the attribution of intentions would not be able to get off the ground. A prerequisite for acquiring the ability to reproduce something is the capacity to learn to distinguish between different sorts of activities, and their meanings.

Discerning among the different activities constituting a given cultural frame requires the supporting role of *artifacts used as scaffoldings for the (re-)production of representings*, that is, as part of activities whose aim (in part) is representing an activity in its distinction from others that can be learned and inherited. Roughly, an artifact represents through its standard use (as part of a practice). Learning how to drive involves acquiring several abilities and knowledge of many norms, many of which cannot be understood as instructions. You might have never learned what a specific traffic signal means, but traffic signals in the context of a driving culture are often self-explanatory. If you see a sign depicting an elephant while driving a road in an Elephant reserve in Eastern India you might infer that elephants can cross in the area and you have to drive carefully. But if the same sign appears in Chicago you would wonder what this sign means. This situated nature of artifactual meanings is closely related to their role as *representings*, which functions in specific practices standardized by social norms and expectations. This is of course an idea that requires more elaboration and examples. But what is important for us now is that such situated nature of artifacts representations is related to the way in which an artifact forms part of a given practice. Think of an instrument like a stethoscope. This is closely related to medical practice, and as is usual with instruments, you have to learn how to use them as part of learning a practice. But learning to use it is learning a way of representing through its use (as part of a diagnosis, for example). To use it as part of a practice is a representation of the artifact in the relevant sense.[5] If the artifact is used in different practices the artifact represents different things in different practices. But the different representations share a representing, a capacity associated with artifacts that form part of different practices and that contribute to the reproduction of different representations.

It is clear that artifacts and their uses change. But there is no reason to expect that the cultural processes associated with changes in artifacts can be understood as an index of changes in (shared) beliefs. At least prima facie, if we focus on artifacts and their use it seems that what needs explanation is not shared beliefs but shared practices. But in order to fully appreciate the importance of artifacts in the evolution of cognition and culture one has to realize that artifacts are not merely things having a function. As we have seen, proofs, theorems, and other sort of normative and routine structures are artifacts. The stability we associate with an artifact like a stone tool should not be seen as simply inherited from the properties inhering in material things, because for example, a simple stone for breaking nuts already involves its use within a practice that requires searching for the right sort of stone. Material culture rather should be seen as forming part of the normative horizon of cultural practices that from different perspectives can be seen as evolution of cognition or as cultural evolution. Another example culled from science is useful in making this point.

**6. Diagrams as technology of cognition.** The discourse about human culture often pointed to the importance of literacy in the development of organizations (and institutions) that are more complex than cultures without systems. Writing allows for ideas, standards (and among them arguments) and norms to be "fixed" or anchored (to a text), and thus to have generalizing power, in the sense that ideas and standards can be reproduced in different contexts as concrete exemplifications of general norms (Goody 1986; 2008). In this way, written norms and standards become abstract representations of more concrete norms. *They are abstract in the sense that they have the capacity to reproduce its representings in the context of the relevant (lineages of) practices.* The formulation of codes and norms encourage its spreading through specialization, which involves tailoring the norm for more specific contexts and thus promotes its diversification. Goody has shown how written norms can be seen as part of systems of norms than become more and more abstract through its dispersion and specialization in more and more specific contexts (and thus more concrete too).

Implicit in this account of writing as technology of the intellect is a thesis about what constitute culture. Culture in this sense is not the mere information collected by a set of people. Rather, culture is something learned and inherited through processes that involve organization related to the diversification and/or specialization of norms, the latter of which spread through (the use of) artifacts as representings. As we have seen with the example of diagrams in Euclidean geometry, this account is not exclusive to the technology of writing, but also gives us a good characterization of the way technologies of cognition play a role in the production of culture. One of the key points explored by the well known laboratory of visual inference (see Allwein and Barwise 1996) has been the recognition that diagrams are not cognitively transparent, that is, that their concrete instantiations and the concrete ways in which the technology of drawing them has been mastered matter for the way in which they were used and interpreted. What the diagrams mean is not something that can be understood aggregatively, as if the diagrams where partial description of one homogeneous representation space (Martínez 2009). It is only taking in consideration the role or situation of the diagram within a wider task, which is conditioned by its history of use, that the diagram means something. This is of course something quite obvious if we think of diagrams as technology[6].

Kaiser (2005) provides another detailed study of the role of diagrams as crucial scaffoldings for scientific understanding. He shows how the ways in which

Feyman's diagrams were drawn, used for calculation and understood were quite diverse through the decades during which they spread and became part of the standard tool-box of a physicist. Kaiser shows in wonderful historical detail how diagrams spread and what applications they served, offering a good example of the way technologies of cognition evolve. In order for Feyman's diagram to spread and become standard tool, physicists had to be trained to interpret and evaluate the results in a specific manner, and different sub-communities in physics had different standards of interpretation that were associated with different experimental or theoretical cultures; the diagrams achieved a canonical meaning and use as the technology of cognition went hand in hand with the capacity of communities of physicists to train a new generation of physicists in ways of doing things differently.

It is crucial to Kaiser's approach and for our purpose in this paper that contrary to the assumption common in the sociology of knowledge and in science studies, scientific diagrams (and in general artifacts) are not immutable, quite the contrary, they are highly mutable. Kaiser shows that there are very clear differences between different groups of practitioners and that such differences tend to be inherited through their lineages, which form around the teaching and learning of the discipline in informal personal interaction (postdocs working close together). In other words, diagrams are highly mutable kind of technology. It is not hard to see that what we have said about diagrams can be said about other pictorial devices. A similar account can be given of the role of heuristic devices and heuristic patterns of reasoning in every day reasoning, in moral, scientific and other institutionalized reasoning patterns. Such patterns of reasoning should be seen as a technology of cognition forming part of the production of stable representings, which play a crucial role in the diversification and stabilization of practices and traditions of thinking and doing. Thus, technologies of cognition play a crucial role as scaffoldings for the diversification of norms and standards, and thus are a key factor in the evolution of culture.

Models of cultural evolution often try to model changes in beliefs or ideas and implicitly at least sever technology from culture. The sharp distinction between technology and culture that is so often made by social scientists is grounded in a persistent dualism that takes language to be a system of representations encoding mental contents. Through the mediation of language, in this narrative, the mental obtrudes into culture-ideas make history. But the view of language here is simplistic. It is certainly more than encodings. The development of an alternative view like the one suggested above requires advancing an account of those artifact-representations (of which diagrams would be a paradigmatic example) that constitute the technology (of cognition) supporting the production of culture.

**8. Representings as scaffoldings of culture.** The recognition of the importance of the concept of scaffolding as a generalization of development in evolutionary processes in the social context has been developed by Wimsatt and Griesemer (in relation to cultural evolution) and by Caporael in relation to the development of a generalized theory of evolution that avoids the pitfall of universal Darwinism (Wimsatt and Griesemer 2007; Caporael 2003). As the editors of this volume put it in the introduction, -scaffolding abstracts general features of development in such a way that it makes understandable how cultural resources form repeated assemblies which in turn serve as further scaffolding for the development and inheritance of culture. The order in which the configurations of resources turn into stable nodes serving as scaffoldings for further configurations creates "downstream dependencies which entrenches the dependencies in development". (Wimsatt and Griesemer 2007, 244).

In a similar vein, I have suggested that cognitive resources get articulated in what I call "heuristic structures" which serve as scaffoldings for the development and stabilization of scientific practices (Martínez 2003). Theses different notions of scaffolding are closely associated with the view of cultural entities that emphasize social reproduction and the formation of chains of inheritance. Nonetheless it is worth pointing out a difference. Wimsatt and Griesemer borrow from Bickhard's account of childhood development in suggesting that scaffolding creates "bracketed trajectories of potential development through artificially created nearby points of stability" (Bickhard 1992, 35). Here the functional role of scaffoldings is closely related to the idea that in given "windows" of time, scaffolding lowers "fitness barriers" to developmental performances or achievements. Whereas in the sense I use the term scaffolding is related primarily to the way different representings get distributed in practices as implicit structure required for the display of cognitive abilities in socially meaningful space. They are not provisional in time, but rather implicit or in the background.

Cosmologists use the notion of scaffolding to say things like "dark matter scaffolds visible matter". Dark matter in this sense scaffolds visible matter because dark matter has the capacity to produce the phenomena proper of visible matter. Dark matter is an implicit or tacit resource indispensable for the production of phenomena. Scaffoldings are often tacit resources. Kaiser highlights the importance of tacit knowledge in the spreading of Feyman's diagrams in the physics community and relates such importance to its emphasis upon nontextual means of transmission, or more positively, to its emphasis on the role of skills and the learning of such skills to understand the spreading and stabilization of Feynman's diagrams (Kaiser 2005). Such tacit knowledge is a crucial component of what I am calling representings, and their role in scaffolding cultural evolution.

Take for example the way in which medieval masters used earlier buildings as "approximate models" to estimate the stability of a new design (see Mark 1990). These new designs show an increase in fitness through the transfer of knowledge from the use and observation of earlier structures, which thus became scaffoldings for new designs and buildings. In order to play the role of scaffolding the series of buildings in question have to be observed directly, it was not much what could be learned from sayings or drawings. The stresses in the buttressing system or the light in the vault had to be observed with a trained eye. But here observation is not culturally neutral, but is part of vocational habilities that particular persons- say master builders- are trained to perform as part of a given practice and of a tradition of doing things in a certain way.

**9. Culture cognition and Continuity**. At this point we can come back to the problematic as we originally posed it. If culture is information store in human brains then the problema of stability are only a problem about the reliability of the channels of cultural transmission, and can be approximately solved by postulating something like Dawkins memes. In this case “observational learning” (as suggested by Boyd and Richerson 1985) or a similar mechanism has to play a central role in the explanation of the stability, which takes imitation as it main (or only) standard. But if we reject this story, and if we understand culture and cognition as articulated in artifact-representations (representings) that not only extend the brain but provide a supportive environment for activities to constitute units of reproduction, then the spread and the stability of cultural processes can be explained as the result of the robustness of path dependant technologies of cognition that produce such representations. As Brooks suggests, using the case of robotics, to the extent that cognitive architecture with explanatory power is “bottom up”, cognition has to be understood as the result of models of constraints that are the product of evolution of social and cognitive organization. In this case, the stability of culture and its capacity to innovate is explained as a by-product of the evolving interacting structure of those scaffoldings that constitute the entrenched path dependent processes embodied in the evolution of artifacts. Material and symbolic resources become interlinked in the technologies of cognition underlying the evolution of culture.

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**Notes**

[1] A mechanism is a description of a causal relation in terms of *parts* of the mechanism, in such a way that the nature of the parts and the way in which such parts interact among themselves and with the environment allow us to predict and (often to understand) the way in which changes in context will change the functioning of the mechanism. Thus, if we think that there all change can be explained by one basic mechanism that has universal scope the problem of determining the  explanatory scope disappears at once. In this case the only problem remaining would be the elaboration of the details of how the mechanism applies to specific cases. The appeal of talk of a universal mechanism of natural selection is related to this idea.

[2] Of course, sometimes the issue can be reduced to an explanation of the stability of

instructions, but this is often not enough.

[3] See for example several articles in Dunbar et al 2010, and in particular Lehmann, Andrews and Dunbar 2010.

[4] As Coward and Gamble put it: "embodied, vocal material and symbolic resources all become interlinked in the practice of everyday life. However, what we seem to see during hominin evolution is the gradual adoption of material resources to complement our primate heritage of corporal and emotional social strategies" (Coward and Gamble 2008, 1973).

[5] The stethoscope can also represent in a different sense. For example, it can be used as a symbol that tells us that there is a physician in a certain place.

[6] What I am saying depends of course in a certain view of understanding technology. If for example technology is understood as the manifestation or deployment of a well defined kind of "technical action" distinguishable and essentially different from other cultural phenomena then diagrams hardly fit as technology. And if technology is understood as mere collection of artifacts diagrams could be considered technology but the relevance of asserting this is lost. I am thinking of technology as for example Feenberg does. Feenberg characterizes technology as the systematic locus for the sociocultural variables that actually diversify its historical realizations (Feenberg 1999; Martínez 2003).