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Rethinking the Evolution of Culture and Cognitive Structure

Martin Stuart-Fox
School of Historical and Philosophical Inquiry,
The University of Queensland, Brisbane St Lucia, QLD 4072, Australia
e-mail: m.stuartfox@uq.edu.au

Abstract

Two recent attempts to clarify misunderstandings about the nature of cultural evolution (Henrich et al., 2008; Gabora, 2011) came to very different conclusions, based on very different understandings of what evolves and how. This paper begins by examining these two 'clarifications' in order to reveal their key differences, and goes on to rethink how culture evolves by focussing on the role of cognitive structure, or worldview.

Keywords

sociocultural evolution – universal Darwinism – culture – cognition – worldview – niche construction

Introduction

The last quarter century has witnessed a remarkable upsurge in the application of evolutionary thinking across the social sciences generally, and to the study of culture in particular. Cultures, it is now widely accepted, adapt over time in response to the challenges posed by differing environments, by means of mechanisms analogous, in one way or another, to those of biological evolution, including the selective transmission of variation and the drift and flow of variants (Whiten et al., 2011). Debate remains fierce, however, over the relationship between biological and cultural evolution, over the nature of cultural variation and its replication, and over the levels and outcomes of cultural selection.

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Two recent studies attempting to dispel misunderstandings about and clarify the nature of cultural evolution (Henrich et al., 2008; Gabora 2011) come to quite different conclusions, however. Comparison of the two reveals that both agree that culture does evolve, and that the process can be modelled by drawing on biological analogies. But while Henrich et al. (2008) take the mathematical models of population genetics as paradigmatic, thereby accepting that cultural evolutionary processes are essentially Darwinian, Gabora concludes that "culture evolves through processes similar to those by which the earliest life forms evolved prior to the emergence of the genetic code" (Gabora, 2011, p. 62). In other words, for Gabora cultural evolution is not a Darwinian process at all.

This article attempts to reconcile the two approaches by rethinking what culture is and the role that cognitive structure plays in its evolution.

Five Areas of Difference

Henrich et al. (2008) identified their five misunderstandings about cultural evolution specifically in the context of the debate over whether or not 'memes' can be understood as discrete, gene-like cognitive replicators. Their first point is that the distribution of mental representations (which they take memes to be) brought about by social transmission and learning can be usefully modelled using population dynamics, whether or not such representations are discrete. All that is necessary is for representations to be under selective pressure from 'cognitive attractors' (constituted by the underlying mental and psychological processes involved), which effectively favour the retention and transmission of some representations rather than others.

In a sense, this places cultural evolutionary theory in a similar position to biological evolution prior to the discovery of genes and genetics. No matter how selective pressures are exerted through the cognitive processes involved in cultural transmission and learning, the effect will be to change the distribution of cultural traits in a way similar to that in which natural selection changes the distribution of biological traits in a species, whether or not we understand the actual mechanisms at work at the cellular level. This is not to say that what happens at the cognitive level in cultural evolution is unimportant. It is just to claim that, just as Darwin explained biological evolution through the operation of natural selection without understanding the replicative mechanism involved, so cultural evolutionists can explain cultural evolution by reference to cognitive selection without understanding all the underlying mental mechanisms involved.

This is a perfectly valid position to adopt, but it leaves an uncomfortable void. We know how significant genetic, and indeed epigenetic, mechanisms have been in fleshing out biological evolutionary theory, so if cultural evolution is analogous to biological evolution, a convincing cultural evolutionary theory cannot ignore what goes on at the cognitive level – especially at a time when cognitive neuroscience has made such progress.

Gabora (2011) seizes upon the cognitive void at the heart of the population modelling approach by focusing on the instantiation of mental representations. Neurons, she points out, either fire or do not, so neurons, or synapses (Aunger, 2002), may provide a basis for discrete mental representations. But we know that representations are recalled to mind by the activation not of single neurons, but rather of distributed neural networks connecting centres of memory formation (notably the hippocampus) with executive centres in the neocortex. In other words, they require large numbers of neurons to fire, many of which may also fire during the instantiation or recall of other representations.

That a specific representation is instantiated by a distributed neural network parts of which contribute to other such networks does not, however, mean that specific networks are not discrete, for activation of just a particular network will still be necessary to bring a specific representation to mind. Nor would it matter, as Gabora (2011) seems to think, that elements of a particular network also form part of another or other networks, for the activation of the whole network would be required to bring that quite different representation to mind. So 'overlap' between networks in no way undermines the possibility that each is discrete, for it is activation of the network as a whole that instantiates or recalls a specific representation. Attributes of a complex concept like 'democracy', for example, are not instantiated by separate sections of the neural network whose activation recalls the word 'democracy' to working memory, but by the activation of connected attribute networks whose relationship to the network instantiating 'democracy' is hierarchical. So the different meanings 'democracy' has for different people will depend on just which hierarchically-related attribute networks are activated by recall of the word to working memory. To reiterate, the fact that representations are instantiated by distributed neuronal networks does not mean that specific networks cannot be discrete.

The second misunderstanding addressed by Henrich et al. (2008) is the belief that a cultural replicator exhibiting the properties of fidelity, fecundity and longevity (Dawkins, 1982) is required for cultural evolution to be adaptive and cumulative. On the contrary, they argue, though the existence of such a replicator would be sufficient for a Darwinian evolutionary process to occur, it is not a necessary condition. What is necessary for cultural evolution to take place is that the 'average characteristics' of a population be replicable, which even blended and error-prone forms of cultural transmission can achieve through conformist social learning.

Gabora's response is to maintain that for cultural evolution to be Darwinian, selection processes must conform much more closely than Henrich et al. assume to the formal requirements for the operation of natural selection, the 'key features' of which are that inherited information is sequestered, that a distinction is maintained between genotype and phenotype, and that no acquired traits are transmitted. Since none of these conditions hold for cultural evolution, Gabora argues, the process cannot claim to be Darwinian.

By insisting that a tight analogy be drawn between cultural and biological evolution, Gabora raises the latter to paradigmatic status. But this is unnecessary. Rather than cultural evolution being the close analogue of biological evolution, both are better understood as instances of the generalised evolutionary process known as Universal Darwinism, which states that evolution will occur in any population of variable entities in which, under selective pressure, variants are differentially replicated. For culture to evolve, it is not necessary for Gabora's 'key features' of natural selection to apply, so long as sociocultural processes differentially favour the replication of some cultural traits over others, as biased social learning does. What cognitive mechanisms might achieve this will be discussed below.

The third misunderstanding targeted by Henrich et al. is that the spread of cultural representations in a population is determined primarily by the existing cognitive content of receiving minds (Sperber, 1996; Boyer, 1999). The authors agree that content bias constitutes one determining factor, but they contend that just as important is whether or not individuals whose behaviour expresses a transmitted representation are selected as cultural models by others. The latter rather than the former is more likely to explain the spread not just of adaptive cultural practices, but of maladaptive ones as well.

In reply, Gabora accepts the importance of transmission biases, but credits "the strategic, creative processes that generate and modify cultural content" (Gabora, 2011, p. 71) with being the principal driver of cultural change. She goes on to claim that these processes cannot be accommodated in a Darwinian model of cultural evolution because they entail the transmission of acquired characteristics, which is not permissible in natural selection. This is a curious argument. The cognitive capacities humans possess that enable them to scaffold niche construction in a cumulative way certainly evolved through natural selection. But culture constitutes a 'second inheritance system' (Whiten, 2005), dependent upon cognitive processes that are nested within our biological organisms, through which change occurs primarily in response to sociocultural selective forces. That natural selection plays only a residual role in cultural evolution is hardly surprising, given that the cognitive selection of cultural behaviour evolved precisely to short-circuit the time frame required for the natural selection of behaviour by enabling the inheritance of characteristics acquired through social learning.

The fourth misunderstanding dismissed by Henrich et al. is that the successful diffusion of a cultural trait indicates its fitness. On the contrary, as noted above, maladaptive traits such as consumption of sugary drinks and starchy processed foods may spread widely in the form of fads or fashions driven by advertising or social media. This is because cultural selection is a complex process that takes in psychological, social and ecological factors, some of which may drive selection in opposing directions. But this occurs also in biological evolution, as for example when the continued sexual selection of some trait runs up against predation pressures. The fitness of genes responsible for some sexual indicator involved in mating (colour, behaviour) almost always results from a trade-off between sexual and ecological selective forces.

Gabora agrees that the cultural fitness of a mental representation cannot be inferred from the rate or extent of its spread through a population, since deleterious practices may 'hitchhike' on more attractive or pleasurable ones. But she then goes further to insist that as the concept of biological fitness is measured by the success of transmission of a given gene from one generation to the next (that is, 'vertically'), and because in cultural evolution within-generation 'horizontal' transmission is common, no objective measure of fitness is available. So the very concept of fitness is inapplicable in cultural evolution. This leaves open the possibility, however, as I shall suggest below, of some other way of evaluating the successful transmission of the mental representation(s) responsible for the spread of some cultural trait.

Finally Henrich et al. maintain that the evolution of culture does not require that the variation of mental representations be random, as some have argued (Pinker, 1997). Seeking solutions to specific problems certainly imparts direction to cultural evolution, but a plethora of historical examples show how serendipitous, and indeed random, the creative process usually is (Campbell, 1960; Basalla, 1988; Meyers, 2007). But in any case, as the authors point out, cultural evolution can occur, and be modelled as a population phenomenon, wherever variation is available for selective forces to operate on – no matter what the source of the variation is.

Gabora responds by arguing that culture evolves through the generation of ideas in minds, but that as these reflect our knowledge, experience and understanding of the world and how it works, they are limited to a few possibilities that, far from being random, are inherently likely to be adaptive. So because the creative process produces variants that are goal-driven and strategic, cultural evolution cannot be a Darwinian process.

Overall the essential difference between the two approaches outlined above lies in how closely the analogy between biological and cultural evolution is drawn. Henrich et al. want "the analogy between genes and culture [sic]" to be kept "quite loose", in order to focus on "the actual properties of the cultural system" (Henrich et al., 2008, p. 134). By contrast, Gabora insists on an analogy between cultural change and natural selection so tight as to preclude the possibility that sociocultural selection might differ at all from natural selection. For Gabora, "Darwinian models of culture stand on weak theoretical grounds" because the processes of cultural variation and selection do not conform to "[t]he fundamental structural features of entities that evolve through natural selection" (Gabora, 2011, p. 70) – which leads her to conclude that culture does not evolve through "change in the frequency of heritable variations over generations due to differential response to selective pressure" (Gabora, 2011, p. 77), the very premise on which Henrich, Boyd and Richerson base their prescriptions for a 'unified science of cultural phenomena'.

There is no doubt that Henrich et al. represent the majority view among cultural evolutionists, nor that acceptance of culture as an evolving population of traits does open up the possibility of constructing a unified science of cultural change (Mesoudi et al., 2006). Such a science requires, however, the formulation of theoretical constructs that encourage a productive research program (Lakatos, 1978) stretching across all levels on which sociocultural selection operates, from mental representations to social groups.

Henrich et al. outline such a research program beginning with what they call 'rich psychology' on the basis of which models of population and ecological-economic processes can be constructed. Rich psychology comprises two components of significance for understanding cultural evolution. The first comprises all those psychological factors that influence social learning, while the second covers the processes involved in the cognitive organization, storage and recall of cultural information. How the two are related with respect to the transmission and replication of memes is unclear, however, and plainly this is the level most in need of theoretical clarification. Neither 'memes' nor 'mental representations' are adequately defined – which leaves modelling at the population level dependent on making 'simple psychological assumptions', as Henrich et al. admit. This is hardly satisfactory, and it is unsurprising that the quest of Henrich et al. to construct a unified science of sociocultural evolution ends in a rather lame call for methodological pluralism.

Gabora uses her critique of Henrich et al. to reject the Darwinian model of cultural evolution and replace it by one analogous to the pre-genetic self-replicating processes demonstrated by the self-organizing proclivities of sets of organic molecules. On this basis, Gabora proposes that "what evolves through culture is worldviews, the integrated web of ideas, beliefs, and so forth, that constitute our internal models of the world" (Gabora, 2011, p. 79). Elsewhere Gabora has argued that worldviews (or 'minds') are the basic replicating units of cultural evolution (Gabora, 2004). These 'assemblages' do not change over time through competition for survival, but through interaction with each other in cultural contexts.

Gabora's model of cultural evolution as driven by modifications in self-organizing, low-fidelity replicating worldviews poses more questions than it answers, however, not the least of which is that if, as Gabora states, worldviews evolve idea by idea, what mechanisms and processes are at play? It would appear that ideas differentially contribute to the structure of worldviews as genes do to the structure of organisms, and so could be modelled using population dynamics. But Gabora rejects the possibility that ideas might be replicators on the grounds that they possess no means by which to reproduce structure (Gabora, 2004). All they can do is form part of a larger assemblage.

Rather than follow Gabora further down this path, I want to seize upon what seems to me the most significant component of her model, which is the concept of worldview, the internal model we construct of the world, as something that is both replicated and changes over time. Such a structural concept is conspicuously absent from the populational understanding of culture change espoused by Henrich et al., based on analogy between the evolution of a species resulting from changes in the distribution of genes, and the evolution of a culture brought about by changes in the distribution of memes or mental representations. But genes do not construct species: they construct organisms. And no more do memes or mental representations construct cultures. What they construct is models of the world, or worldviews.

In what follows I shall attempt to show that Gabora's concept of evolving worldviews is compatible with the distribution modelling favoured by Henrich et al., provided cultural evolution is grounded not just in cognition broadly understood, but in cognitive structure. I shall do so by beginning with culture and working back to cognition.

Culture

Culture has been defined in a bewildering variety of ways. Kroeber and Kluckhohn (1952) famously combed the anthropological literature to that point to discover 164 definitions of culture, which they attempted to organise into categories (normative, structural, genetic, and so on). Since then definitions of culture have proliferated: no two basic texts agree on a common definition (Cronk, 1999). Sir Edward Tylor's classic definition included not only the "knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society" (Tylor, 1871: 1), but also every form of human behaviour that in any way shapes the environment in which we live, and every artefact produced as a result of that behaviour (material culture). This latter "wondrous and gargantuan category" (Schneider, 1973: 119) includes every conceivable item made by human hands, from the kitchen sink to the artistic products that comprise culture in a narrow sense.

For Tylor culture had three dimensions: cognitive, behavioural and material. Material culture came to feature less in definitions, however, because "material culture patterns are in the first place material behaviour patterns – patterns of socially acquired actions and activities condensed in solid form" (Clark, 1968: 399). Of the twenty definitions of culture gathered by Lee Cronk from anthropology textbooks published in the 1990s, only four make any reference to material culture (Cronk, 1999).

Almost all definitions of culture refer to behaviour, but seldom exclusively. Culture has been defined as "the totality of learned socially transmitted behaviour" (Keesing, 1976, 268) or as "minimally a pattern of behaviours (or their material manifestations or informational content) that is socially transmitted" (Janson and Smith, 2003, 57). Of Cronk's twenty textbook definitions, nineteen mention behaviour, all in conjunction with some aspect of cognition.

It is evident that behaviour can claim no ontological priority, however, for behaviour is always an expression of mental processes on the one hand, and generates some social and/or material effect on the other. The relationship between behaviour and cognition figures in all more inclusive definitions of culture (Bohannan, 1973). Marvin Harris took culture to be "the total socially acquired life-style of a group of people including patterned, repetitive ways of thinking, feeling, and acting" (Harris, 1980: 106), a definition which stresses social learning, as many do. Recently, however, some evolutionary theorists have downplayed behaviour. Alex Mesoudi, for example, makes a point of defining culture as "information rather than behaviour" (Messoudi, 2011: 3).

Because behaviour depends upon mental content, several definitions of culture focus primarily on mental states. An uncompromising case for a purely mental conception of culture was made by cognitive anthropologist Ward Goodenough, who defined cultures as "organized systems of standards for behaviour" (Goodenough, 1971). These standards inform the human mind. Culture is the individually interiorised product of human learning, which Goodenough divides into four categories: perceptions of and concepts about the real world; propositions and beliefs about the cause-and-effect relationships between events; values and sentiments; and principles of action, which are "recipes for accomplishing particular ends" (Goodenough, 1999).

Increasingly scholars have come to define culture in terms of the information acquired through social learning (Mesoudi et al., 2006), a definition not only attractive to evolutionary theorists impressed by the theoretical achievements of population genetics, but also to anthropologists (Flinn, 1997; Henrich and McElreath, 2003) and social psychologists (Baumeister, 2005). Those who define culture as information are mainly interested in its transmission and inheritance rather than in the scaffolding role it plays, its creative development, adaptive potential, or historical trajectory. Thus Richerson and Boyd define culture as: "*information capable of affecting individuals' behaviour that they acquire from other members of their species through teaching, imitation, and other forms of social transmission*." (Richerson and Boyd, 2005, p. 5; original italics). Mesoudi (2011) agrees that culture is information acquired by individuals through social transmission, which manifests in the form of knowledge, beliefs, attitudes, norms, preferences and skills.

In all such definitions of culture as information, 'information' acts as a blanket term, whose effect is to mask the complexity of what goes on at the level of cognition. To equate culture with information impoverishes it both as concept and as process. The principal source analogy for referring to what we hold in memory as 'information' derives from the misleading 'computer-metaphor framework', the use of which in cognitive science has been condemned by one prominent neuroscientist as a "less-than-helpful idea" (Damasio, 2012: 45), and by another as predestined to fail by virtue of its "inherent incompatibility with evolutionary and developmental concepts" (Velichkovsky, 2007: 3). It is all too easy to assume that what computers and brains both process is information, and that they do so in essentially similar ways. As something that exists in uniformly accessible form, whether 'out there' in the 'cloud' or within the circuits of a computer, 'information' is endowed with a spurious epistemological status, which derives from its material existence in binary code. That is not to suggest that no errors occur in information transmission, but that processing (errors and all) is done in the same way by the same program in every (virus-free) computer. It is this sense of computer information as unproblematically transmitted and replicated that tends to carry over into thinking about cognition.

To suggest that whatever is held in mind, from sensory images to concepts and beliefs, constitutes 'information' is an unwarranted simplification to the point of distortion, because it fails to take account of how the brain builds cognitive structure, how this develops in a growing child through social learning and symbolization (DeLoache, 1995), and how cognitive structure influences the selection of behaviour. 'Information' fails as an explanatory concept applied to human cognition because it does not take account of the transformations brought about through cognitive re-processing to reduce inconsistency and dissonance – of a kind no computer performs. As the great French neuroscientist J.-P. Changeux long ago pointed out: "The human brain works in ways that are antithetical to the input/output model cyberneticists have long taken for granted. Rather it continuously projects onto the world spontaneous internal 'mental representations', which it then tests against an intrinsically meaningless external reality." (Changeux, 1996, 76).

What is stored in human memory as a result of cognitive processing is never unproblematic information of the kind crunched by computers, but rather inferred interpretations and constructed meanings, which, though drawn from the same sensory data, may be quite different in different individuals and so carry quite different behavioural implications. Note that making the case for meaning rather than information as central to cognition is hardly new: it has extensive support across a range of fields, including evolutionary biology, anthropology, cognitive science, linguistics and philosophy (Dretske, 1981; Putnam, 1981; Johnson, 1987; Lakoff, 1987; Langacker, 1991; Varela et al., 1991; Rose, 1993; Turner, 1994; Fauconnier, 1997; Strauss and Quinn, 1997; Lakoff and Johnson, 1999; Torey, 1999; Poirier et al., 2005).

The human mind is not an information processor: it actively constructs a model of the world, and thereby creates meaning, which is something no computer can do. Just as the scientific revolution of the seventeenth century gave rise to a mechanistic worldview, so the computer revolution has given rise to a prevalent conception of cognition as information processing that is just as misleading. It is high time to dispense with the computer analogy in relation to both cognition and the evolution of culture. We need not dispense with the term 'information', however, provided it is confined to what is presented to momentary sensory memory through the automatic processing of the raw data (light waves, sound waves) monitored by our sense organs. We can have confidence that sensory information reflects reality because sensory organs and the way they function have been honed by natural selection – though even so errors can occur, as when a rope is taken for a snake, and ambiguities instigated, as when we are confronted by the graphic art of M.C. Escher or the surrealism of René Magritte. What happens to this sensory information there-after depends both on the psychological processes by which it is selectively assimilated (through memory formation) and the cognitive structure of the brain as this has already developed. Together structure and process construct meaning by interpreting the tiny fraction of sensory information to which attention is directed.

Defining culture in terms of information, while it has focused attention on cognition, has been detrimental for understanding cultural evolution because it has neglected its adaptive purpose, its driving dynamic and its cumulative impact. These oversights are corrected if culture is understood in terms of niche construction (Odling-Smee et al., 2003). Across the animal kingdom, from termites to beavers, organisms behave so as to modify their environments in ways that are adaptively beneficial. Such behaviours are for the most part hardwired, but in more than one evolutionary line social learning plays a supplementary role in transmitting niche-forming behaviours. The primate line is the supreme example, to the point where in humans social learning has become the principal means by which niche-forming behaviour is transmitted. Culture comprises all the processes by which human groups transform their environments – the material niche they construct through ploughing and planting, the domestication of animals, the building of houses and cities; the behaviours that not only produce the material niche, but also the social organisations and institutions through which we cooperate to do so; and the cognitive processes by which we learn and initiate those behaviours.

To conceive of culture as niche construction is to restore Tylor's understanding of culture as three dimensional. Its adaptive purpose it to modify the natural environment in evolutionary beneficial ways, as measured by increasing inclusive fitness. For each successive generation, the niche already constructed is the environment to transform. Thus as culture accumulates, the potential for further transformation increases; that is, culture evolves more rapidly. And yet at the same time in developed societies the reproductive benefits of niche construction as measured by inclusive fitness decline, as people choose to have fewer children. So what then drives cultural evolution?

The answer, as I indicated above, is that cultural evolution has itself evolved to become a second inheritance system. Biological evolution is driven by a universal innate urge to reproduce, but what drives cultural evolution? Very simply, the reward system of the brain. Behaviours that in themselves or through the feedback they produce generate positive rewards in the form of dopamine and other opioid peptides are repeated, while those that do not are not. Rewards are experienced as positive emotions, which in humans are remarkable for their variety (Rolls, 2005). We seek to maximise pleasure, or more broadly psychological satisfaction, not just for ourselves, but also for those for whom we harbour emotional concern, from those for whom we have deep affection to those for whom we feel sufficient sympathy or empathy to act in part for their benefit – that is, for all who are significant for us in some way. So what drives the selection of cultural behaviour is not the urge to reproduce, though sex and having children remain major sources of pleasure, but rather the emergent urge consciously to experience satisfaction. We select cultural behaviour not to maximise inclusive fitness, but rather to maximise inclusive satisfaction (the sum of personal satisfaction plus the estimated satisfaction experienced by significant others).

In summary, from an evolutionary perspective we can make the following claims. The evolution of culture is firmly grounded in biological evolution: the capacity for culture evolved in response to natural selection, because it increased the inclusive fitness of early hominins – to the point of enabling the species in which it was most developed (*Homo sapiens*) to displace all competitors. Cultures are continuously adaptive (Alvard, 2003): they enable human groups rapidly and effectively to adjust to new environments, both natural and those partly or wholly constructed by culture itself (in the form of a cultural niche). Cultural niches both protect against 'hostile' forces, and increase opportunities to experience satisfaction and pleasure. Cultures are cumulative: they use their own constructive achievements as scaffolding for new development. Cultures are produced through the interaction of cognition, behaviour, and material production, through a complex developmental process that cannot be reduced simply to the transmission of information, or the inheritance of ideas, or the imitation of behaviour, or the spread of material artefacts. Cultures are both individual and social: cognition is individual, but much behaviour, though performed by individuals, is cooperative and communal, designed to create social institutions and material products that are more than the sum of individual contributions. Cultures are transmitted through social learning and teaching: vertically (from parents to offspring), obliquely (from teacher to student), horizontally (from peers), and even vertically in reverse (from mature offspring to parents and grandparents) as the rate of technological change quickens. Finally and most importantly for a theory of cultural evolution, cultures are population phenomena: they are maintained through the repeated performance of behaviours, and altered through changes in the frequencies with which different behaviours are performed.

Culture is best conceived, therefore, as a dynamic process of 'repeated assembly' (Caporael 2003) brought about by the interaction between cognition, individual behaviour, social group action, and material production, lubricated by the feedback loops between them. Cultures continuously evolve through multi-level selection – not as some kind of 'super-organism', but as the variable consequences of the interaction over time of the thought and behaviour of individuals and the coordinated activities of organised groups. These interactions produce both social institutions and material products, from manuscripts to skyscrapers, which comprise a large part of the environment to which each new generation must adapt. The influence of the past channels the direction of the future.

The form that the material cultural niche takes is determined by the selection of behaviour, including notably forms of communication. The selection of behaviour in turn depends not on how the world actually is, in some objective sense, but on how the world is understood to be: that is, it reflects the model of the world constructed in individual brain/minds. To understand the role of cognition in the evolution of culture, therefore, we must understand how worldviews are constructed, and how they influence cognitive selection.

Cognitive Structure

Brains evolved initially to coordinate perceptual inputs and activate motor responses. Larger and more complex brains evolved to do this through drawing upon stored learned reward and aversion responses. To be useful, what was stored had to be immediately accessible in relevant circumstances – which required it to be structured. In animals, sensory information in relation to food, danger and mating is generalised in the form of natural categories (Barsalou, 2005), and structured as analogue 'cognitive maps' (Portugali, 1996), both of which evolved to facilitate rapid motor responses.

In the hominin line, causal thinking evolved to interpret natural signs, a skill of value in locating food sources and in tracking game. In time, causal thinking was extended to account for human behaviour in terms of motivating mental states (so-called 'theory of mind'). As a result, in human beings cognition came to constitute a nested selective system whose adaptive purpose was to enable the conscious choice of behaviour, just as the immune system evolved as a nested system to select the appropriate antibodies to neutralise invasive antigens (Hull et al., 2001) – both through natural selection. Cognitive maps formed through the integration of sensory modalities – visual, auditory, olfactory – served as the scaffolding in the hominin line for construction of interpretive 'causal maps' of the kind that infants begin to form from an early age (Gopnik, 2000). Subsequently, the differentiation of memory opened the way for models of the world to include both semantic 'concept maps' and representations of self as agent, while the syntax of language enabled mental structure to be symbolically communicated.

Natural categories constitute the basic components of worldview: recalled to working memory they enable inferences to be drawn and explanatory theories to be constructed about the real world (Thagard and Toombs 2005). Natural categories stand in a superior hierarchical relationship to their defining features and properties, and in a nested relationship to more comprehensive categories (as in folk biological classifications). Cross-cultural research into folk biology reveals a universal tendency to conceive of natural kinds hierarchically. In constructing nested hierarchies of categories, the mind creates progressively more inclusive abstract kinds, as in the (learned scientific) hierarchies cat, mammal, vertebrate, animal; and sycamore, tree, dicotyledon, plant. Features of categories can be combined in novel ways to produce imagined composite images, as exemplified in combined human/animal forms dating back to Palaeolithic cave art, and in conceptions of gods and spirits possessing extraordinary powers (Boyer, 2002).

How categories are formed and how they are represented in brain structure are contested by cognitive psychologists (McGarty, 1999). The classical view that categories are defined by their properties and boundaries has given way to acceptance that category formation is influenced by both internal (within category) and external (between categories) structures (Lakoff, 1987; Medin and Atran, 1999). Much of the study of category formation has focused on the cognitive development of children. Early childhood research has shown that "the conceptual system is categorical from its inception", and that its structure is hierarchical (Mandler, 2002, p. 315). Recent neuroscientific research confirms that sub-categories are nested within more general categories. Indeed "general-to-specific hierarchical organization of information-processing units represents a general organizing principle throughout the brain" (Tsien, 2007, p. 40).

Categories are instantiated by distributed networks of neurons, which link to other such sets in semantic memory (Rolls and Treves, 1998). Like definitions in a dictionary, one category necessarily adverts to another. The semantic system also richly interacts with the self-system grounded in the individual experience organized sequentially and recursively in episodic memory. With the evolution of extended working memory and language, possibly in conjunction (Coolidge and Wynn, 2005), categories could be named and examined in working memory through associating visual and linguistic dimensions by means of the multimodal 'episodic buffer' (Baddeley, 2000). The symbolic association of words and categories – whether of natural objects or of abstract concepts – enabled the definition of categories in terms of attributes and properties and relationships between them to be communicated and shared.

Hierarchical relationships between categories are classificatory, but connections between categories are structural. Of most significance in constructing a mental model of the world are causal relationships whose projection into future scenarios influences the selection of behaviour. The evolutionary benefit of constructing causal connections lay in the advantage gained by imagining alternative courses of action (planning hunts, moving around a territory) (Suddendorf and Corballis, 2007). It was but a step from there, facilitated by parallel mental processing, to the meta-representation of causal connections as symbolic and metaphorical meanings.

By instantiating inferences about the natural world, causal connections between categories constitute structural components of worldviews. Causal connections are not the only constructs of worldview – other relationships include comparative, symbolic, analogical and metaphorical – but they are the most significant. But note two things about all inferential causal relationships: they are theoretical constructs of the brain/mind; and as such they are essentially hypothetical and require confirmation.

Human brain/minds evolved to construct causal models of the world; that is, they evolved to seek and infer causal relationships wherever conceivable, even where they do not exist. We make such inferences on a daily basis, particularly with respect to individual behaviour: we do not simply observe that someone is in a bad mood, we seek a cause (he must have had a poor night's sleep, his supervisor must have reprimanded him). Repeated observation and the communicated experience of others provide the principal means of confirmation. Most causal relationships included in worldview are transmitted to us ready made during enculturation by parents or teachers whom we accept as knowledgeable or expert, so no further confirmation is required.

Building a mental model of the world is a developmental process whose functional outcome is to replicate core components of the worldview of a social group (always allowing individual variation). The underlying brain processes (category formation, instantiation of neural connections, and so on) are innate, but cognitive structure can be consciously assembled and accessed. Worldviews are continually updated and modified throughout life in response to new experiences and social learning through instantiation of new cognitive connections. New connections may also result from rational thought designed to solve problems or maintain consistency (in order to reduce cognitive dissonance). With age, however, the flexibility required for cognitive innovation and reorganisation tends increasingly to be lost.

The mental models we construct of the world (worldviews) are both comprehensive and internally consistent. They include not only the real world we personally or vicariously encounter, but also the world as we know others believe it to be, and even virtual and imagined worlds as fictional constructs. We can think of worldview as comprising a 'core' belief structure integrated closely with the self-system and associated desires, values or goals, plus a 'periphery' comprising all that we know, but reject, about how others think and behave. The former constitutes the usual basis for the selection of behavior, the latter normally does not (except when engaging the holders of such beliefs). The assignment of evidence that conflicts with core beliefs to the periphery of cognitive structure protects those beliefs, minimizes cognitive dissonance, and so reduces anxiety.

In summary, worldview comprises the structured organisation of knowledge about the world held in semantic memory plus the self-system constructed in episodic memory from the images of experience. The two systems are massively interconnected, with the latter providing the foundation for the concept of self as agent, animated by feelings, principles and goals, which figures in the epistemic causal model of the former. The content of worldview in this broad sense clearly influences the selection of behaviour in relation to given circumstances (not all mental content has behavioural consequences. One may possess knowledge and never act upon it, and have plans never fulfilled. Many dreams and fantasies are never translated even into the action of recounting them. Such uncommunicated mental content is not, of course, directly subject to sociocultural selection) – which places the replication of worldview, as Gabora recognises, at the core of cultural evolution.

The Replication of Worldview

In what way, therefore, are worldviews replicated? Not through some mysterious cultural osmosis, and not in exact detail. Rather what get replicated, through a developmental process that takes years of teaching and learning, are broadly similar structures comprising conceptual relationships between higher level categories of the classificatory hierarchies that encompass the world as we encounter it. In my analysis, there are four such hierarchies: the natural world we encounter through our senses comprising both inanimate and animate objects; the social world, from individuals to organised groups, including their political, social and economic relationships; the self as agent, whose hopes and fears, fantasies and desires, moral principles and aspirational goals, define the parameters of interaction with the natural and social worlds; and our conceptualisation of the unseen powers at play in relationships within and between self and the social and natural worlds, whether conceived as gods and spirits, or energy and forces. Worldviews are structured by how these hierarchies are conceptually related to each other. Worldviews are replicated through the neural instantiation of defining structural relationships in the receiving brain/mind. These relationships, causal and other, are established between categories, whether natural or abstract. The development of structure is thus incremental, one neural connection at a time. The brain/mind has evolved to create this structural model of the world through natural selection – including processes generalising sensory information to form categories, organising categories hierarchically, differentially processing and storing kinds of sensory information (visual, aural), and continuously seeking to infer causal relationships. But note that the connections established between categories are always contingent on environmental circumstances; that is, on cultural content. Cognitive relationships comprising worldview are not hardwired.

Enculturation transmits the component incremental relationships structuring worldview through the medium of language and demonstration. Now words name categories, whether of objects, or properties, or activities, or events. Learning language requires an association to be established between symbolic sounds and what they represent; that is, between sounds and the *pre-existing* categories they designate. Words do not transmit categories from one mind to another: they trigger recall to working memory in the brain/mind of the receiver through activation of neural networks that are already primed. Categories formed by brain/minds of objects and events in the natural world are universal across the human species: how they are causally connected can differ. Variation is greatest, however, with respect to composite and abstract categories (satyrs and sanctity), for these are conceptual constructs, made up of relationships between categorised attributes and properties that to be included must also pre-exist. And if one or more attribute or property is not present in the receiving brain/mind, then the category formed will not exactly reproduce the one in the mind of the transmitter – which is why complex concepts like democracy can mean different things to different people.

So if categories, and much less images, are not the mental representations whose distribution Henrich et al., model in their demonstrations that culture evolves, then what is transmitted from one brain/mind to another in order to replicate worldview? The answer, rather obviously, is that what is transmitted are the connections that exist in the transmitting mind between categories, for it is the reconstruction of these in the brain/mind of the receiver that contributes to the developing mental model of the world. Such connections, as we have seen, are of several kinds, the two most important of which are causal and hierarchical, specifying respectively how categories impact upon and interact with other categories; and how properties and attributes stand in relation to categories and those categories to more inclusive ones. If natural categories are representations, then connections conceived as relating one to another are meta-representations of these relationships. These are the structural elements that must be transmitted from one mind to another in order to replicate worldviews. The mental structures so formed are not exact replicas, but rather sufficiently similar to permit each successive generation to function within the sociocultural niche bequeathed to them.

Previously I have coined the term 'menteme' for the meta-representations of the relationships that structure worldviews (Stuart-Fox, 1986). I did so in order to differentiate these neutrally instantiated connections between categories from the plethora of confusing definitions of 'memes', while preserving the latter term to refer to the communication of complex combinations of mentemes, as would be required to explain relationships between composite abstract concepts like, for example, science and modernity. Mentemes can exist in alternative forms (sickness causally linked to malign spirits or nasty germs), the differing distributions of which can be modelled in evolving populations.

This brings us back to the question of how close an analogy needs to be between cultural and biological evolution for the former to count as Darwinian. The concept of mentemes to describe the structural components of worldview that we meta-represent and communicate through language permits an analogy to be drawn sufficiently close to count as Darwinian, along the following lines. In interaction with the environment through available sensory information, mentemes developmentally construct worldviews in a way analogous to how genes, given available environmental resources, developmentally construct organisms. But whereas organisms are phenotypes directly subject to natural selection, worldviews are not directly subject to sociocultural selection. Selection is indirect, via behaviour. An individual's behavioural repertoire is thus the sociocultural analogue of the phenotype – and worldviews are equivalent to genotypes, which shape (phenotypic) behaviour in response to environmental conditions.

With respect to behaviour, constructing a worldview is like selectively assembling a genome instead of inheriting one randomly assorted, a process that shortcuts natural selection. The existential purpose of sociocultural behaviour is to shape a niche conducive to the goal of maximising inclusive satisfaction – however that is experienced with respect to self and significant others. But we select behaviour in the face of pressures exerted by the behaviours of others in pursuit of different, often conflicting, goals. For this reason, those with similar goals tend to form cooperative groups to pursue them. So selection in sociocultural evolution operates on a series of levels. At the cognitive level, worldview is selectively constructed in relation to an already existing sociocultural niche constituted predominantly at first by the circumstances of parents and close kin, subsequently augmented by teachers and peers. Consciousness permits behaviour to be selected from alternative scenarios previewed in working memory, on the basis of which is most likely to produce a satisfaction maximizing outcome. Selection of behaviour at this cognitive level is vicarious: only after a behaviour is enacted is it subject to sociocultural selection. The repertoire of behaviour for any actor runs from reflex action, to frame-governed behaviour in response to environmental cues, to chosen individual actions, to the rule-governed behaviour, or practices (Runciman, 2009), required to fulfil social roles and cooperate with others. Selective pressure is exerted by other individuals, and in the case of rule-governed behaviour, by competitive social groups. In other words, like biological evolution sociocultural evolution entails multi-level selection.

To conclude, therefore, while Gabora (2011) was right to point to the significance of worldview in the evolution of culture, this does not undermine the validity of the population-based modelling defended by Henrich et al. (2008) – provided it is understood that the 'mental representations' whose distributions are modelled are in fact discrete structural elements of worldview.

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