

Foresight in cultural evolution

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Abstract Critics of Darwinian cultural evolution frequently assert that whereas biological evolution is blind and undirected, cultural change is directed or guided by people who possess foresight, thereby invalidating any Darwinian analysis of culture. Here I show this argument to be erroneous and unsupported in several respects. First, critics commonly conflate human foresight with supernatural clairvoyance, resulting in the premature rejection of Darwinian cultural evolution on false logical grounds. Second, the presence of foresight is perfectly consistent with Darwinian evolution, and is found in biology, in the form of open, teleonomic processes such as genetically-biased behavioural learning. Finally, empirical evidence from the social sciences suggests that cultural change appears far less guided and directed, and human foresight far less accurate, than is commonly assumed.

Keywords Cultural evolution · Foresight · Human culture · Mental time travel · Niche construction · Planning · Teleology · Teleonomy

Introduction

Cultural evolution is the theory that human culture changes according to the same fundamental underlying principles—variation, selection and inheritance—that govern biological change (Campbell 1974; Cavalli-Sforza and Feldman 1981; Mesoudi et al. 2004; Richerson and Boyd 2005). Culture, here, is defined as the body of information, such as knowledge, skills, attitudes, norms, or beliefs, that is acquired from other individuals via social learning, rather than acquired genetically or learned individually/asocially. Theories of cultural evolution are relatively old; Darwin himself used cultural examples to illustrate his theory of biological evolution (Darwin 1859, 1871; Mesoudi et al. 2004), and several of Darwin's contemporaries applied evolutionary theory to cultural change in disciplines

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ranging from archaeology (Pitt-Rivers 1875) to linguistics (Muller 1870) to psychology (James 1880). In contrast, within anthropology and sociology a Spencerian (Spencer 1896), rather than a Darwinian, theory of cultural evolution took hold, resulting in flawed and inaccurate theories of cultural change that were unilinear and progressive (e.g. Tylor 1871; Morgan 1877). These flaws persisted into the mid-20th century (White 1959; Sahllins and Service 1960). In recent years, however, there has been a growing movement in several disciplines that has embraced a modern, Darwinian theory of cultural evolution (Mesoudi et al. 2006a), one that is non-progressive, based on population thinking (Richerson and Boyd 2005) and uses the tools of modern biology to analyse cultural change often in a more rigorous manner than traditional non-evolutionary methods, tools such as phylogenetic methods (Mace and Pagel 1994; O'Brien and Lyman 2003; Mace and Holden 2005; Lipo et al. 2006) and population genetic models (Cavalli-Sforza and Feldman 1981; Boyd and Richerson 1985; Laland et al. 1995; McElreath and Henrich 2006).

Despite these recent advances, the theory of Darwinian cultural evolution, and work that draws on Darwinian evolutionary methods to analyse human culture, is still strongly opposed by many social scientists. Several arguments have been deployed against cultural evolution (for reviews see Mesoudi et al. 2004, 2006a; Henrich et al. forthcoming), but this paper will examine one of the most common—the objection that, whereas biological evolution is blind and undirected, cultural change is directed or guided by human actors who possess the capacity for foresight (e.g. Carneiro 1985; Hallpike 1986; Sternberg 1999; Benton 2000; Bryant 2004; Dasgupta 2004; Chater 2005). This supposed difference, according to these critics, necessarily invalidates any Darwinian theory of cultural change. Simply put: evolution is blind, culture is not blind, therefore culture does not evolve. This argument is also sometimes framed more specifically in terms of the randomness of mutation: whereas the source of novel variation in biological evolution (mutation and recombination) is random or blind with respect to subsequent selection, such that useful or adaptive variants are no more likely to arise than are neutral or maladaptive variants, novel variation in culture emerges non-randomly because people can anticipate and plan for successful solutions to problems. This argument is used either to reject any kind of evolutionary approach to culture, or alternatively to advocate a non-Darwinian evolutionary theory of culture, such as the aforementioned Spencerian cultural evolution, where unilinear progression towards a specific, anticipated goal is seen to be consistent with the operation of foresight.

To cite some examples, Hallpike (1986), an anthropologist, argues that “there is no significant resemblance between the *mutation*, the basic source of variation in the Darwinian scheme of things, and social *invention*, which is purposeful, responsive, and can be diffused. Whereas biological variation can be treated as random, social variation is the product of particular societies and cultural traditions, and therefore far from random” (p. 36, italics in original). Bryant (2004), an historian, argues that “... developments in human culture are largely teleological or Lamarckian in form, and result from problem solving and creative intentional choice on the part of reflexive agents,” (p. 465) thereby invalidating Darwinian cultural evolution. Benton (2000), a sociologist, argues that “Darwin’s mechanism of natural selection assumes that mutations are random with respect to the selective pressures which affect their chances of replication. In the case of the activities which lead to social change... human agents act intentionally to produce anticipated outcomes: they are not ‘blind watchmakers’” (p. 216). Finally, Chater (2005), a psychologist, states that “cultural change can be influenced by the collective insights and ideas of generations of intelligent and purposive agents: cultural change operates in a world

of patently “sighted watchmakers,” rather than through the blind watchmaker of Darwinian selection” (p. 356).

In this paper, I hope to show that the arguments above are invalid, because (i) they commonly conflate foresight with clairvoyance (section “Foresight vs. clairvoyance”); (ii) foresight is not incompatible with an ultimately blind Darwinian theory of cultural evolution, as illustrated by the fact that biological evolution exhibits what can be called ‘biological foresight’ (section “Biological foresight”); and (iii) they rest on the assumption that human foresight is highly accurate, reliable and influential, for which there is little empirical support (section “Evidence regarding foresight in human culture”).

Foresight vs. clairvoyance

Many aspects of biological evolution betray apparent intentional design or directedness, such as morphological features that appear to be intentionally designed for a specific function or appear too complex to have arisen by chance (Dawkins 1996). Before Darwin (1859), the best explanation for this adaptive fit and structural complexity was a supernatural, teleological explanation, seeing it as resulting from the action of an omniscient creator who has supernatural powers of clairvoyance. Darwin’s inestimable contribution to science was to explain this apparently intentionally-designed adaptation and complexity as the product of a blind, undirected process of natural selection, sexual selection and other non-teleological processes. A century-and-a-half later, virtually every professional biologist accepts Darwin’s evolutionary explanation for apparent design in nature, and no convincing evidence has been found for the intervention of, or guidance from, a higher, supernatural force in biological phenomena. In the words of Dennett (1995), there are no “skyhooks” in biological evolution—supernatural, teleological explanations for apparent design—only “cranes”—programs or sub-processes that appear teleological but are themselves products of blind Darwinian processes.

It is important to clarify that ‘teleological’ explanations in biology differ from the arguments of the critics cited above regarding cultural evolution, many of whom (e.g. Bryant 2004) also use the term ‘teleological’. Critics of Darwinian cultural evolution typically argue that cultural change is teleological not in the sense of *clairvoyance* (i.e. they do not argue that cultural change is directed by people who have supernatural powers of clairvoyance allowing them to see into the future and make predictions with 100% accuracy), but rather in the sense that culture is directed by human agents who possess *foresight* (i.e. the non-supernatural ability to predict future events on the basis of reasoning or extrapolation from past events). These different senses of teleology, however, are often not explicitly distinguished. To argue, as does Chater (2005), that a Darwinian theory of cultural change is necessarily invalid because cultural change is teleological (in the foresight sense) and biological evolution is non-teleological (in the clairvoyance sense) is therefore conflating these two senses of ‘teleological’. Culture may be teleological in the foresight sense yet non-teleological in the clairvoyance sense. The crucial difference is that while a clairvoyant who could see into the future could guide cultural forms in a direction that he or she knows to be functionally adaptive, no human can foresee the future with 100% accuracy. They may attempt to *predict* the future, but this prediction has no guarantee of being correct. The proper question to address, then, becomes “does non-supernatural, predictive foresight invalidate a Darwinian evolutionary approach to culture?” One way to address this question is by looking at whether biological evolution exhibits any mechanisms that constitute foresight.

Biological foresight

The critics cited above commonly portray biological evolution as entirely lacking in foresight (usually by repeatedly quoting Dawkins' "blind watchmaker" metaphor), therefore implying that the presence of any kind of foresight would invalidate a Darwinian theory of culture. In the following section I take issue with this assumption, and argue that cultural evolution is being judged against an inaccurate portrayal of biological evolution.

Adaptive mutation

The evidence that originally established the biological principle that mutation is blind with respect to subsequent selection was Luria and Delbrück's (1943) 'fluctuation test'. Here, multiple replicate colonies of bacteria are allowed to breed before each is exposed to a virus. If mutations conferring resistance to the virus occur randomly prior to the introduction of the virus, then the bacterial colonies should vary in their levels of resistance and exhibit a predictable statistical distribution. If beneficial mutations arise non-randomly in response to selection, then each sample should exhibit similar levels of resistance. The former was found, supporting the independence of mutation and subsequent selection.

Subsequent experimental work, however, has qualified this basic principle by suggesting some degree of foresight in the mechanisms of genetic mutation. Specifically, subsequent experiments support the concept of 'adaptive mutation' (Rosenberg 2001; Foster 2004), where mutation occurs at a faster rate under conditions of stress (when mutation is most needed) and in regions of the genome that deal with rapid environmental change (where mutation is most needed). For example, Layton and Foster (2003) found that *E. coli* cells, when starved, increase activation of a specific enzyme that in turn increases the mutation rate, thereby increasing the likelihood that a beneficial mutation will occur (e.g. one that allows the *E. coli* to take advantage of a new food source). Adaptive mutation does not imply that unselected/non-adaptive mutations will not also occur at a faster rate in response to selection, or that beneficial mutations are more likely to arise than non-beneficial mutations. So while mutation is not *directed* towards a specific goal (i.e. a particular response to selection), mutation is *adaptive* in that the genome has evolved means of increasing the likelihood that a solution will arise.

Teleonomy and the role of behaviour in biological evolution

Contrary to the claims of the critics cited above, many biological phenomena, especially behavioural phenomena, are goal-directed, in the sense of being directed towards a specific future goal. In an important paper, Mayr (1982a) argued that there are two kinds of goal-directed processes in biological evolution: teleological processes, which are clairvoyant (see section "Foresight vs. clairvoyance") and often associated with either creationism or notions of Spencerian progress, and *teleonomic* processes, which are controlled by programs that are "in part or entirely the product of natural selection" (Mayr 1982a, p. 36). While biological evolution is not goal-directed in the teleological sense, it is entirely legitimate to describe biological evolution as teleonomic. Indeed, as Mayr notes, significant advances are made in evolutionary biology by asking teleonomic 'why?' questions (e.g. for what purpose did phenotypic feature X evolve?), as long as the answer is given in

terms of a history of non-teleological Darwinian evolutionary processes such as natural or sexual selection (i.e. Dennett's "cranes").

Behavioural learning is a good example of an open, teleonomic process. The primary biological function of behavioural learning is to track aspects of the environment that change too rapidly for the main genetic program to track, such as change that occurs within generations (Plotkin 1995). As even short-term environmental change is usually to some degree predictable, behaviour is often guided by genetically-specified biases that increase the probability that the learned behaviour is biologically adaptive (Lorenz 1969; Gould 1986)¹. Well-established examples include the predisposition in rats (and many other species) to associate gastric illness with tastes and odours rather than sights or sounds (Garcia et al. 1955; Seligman 1970), and the predisposition in honey bees to learn to identify flowers on the basis of a hierarchy of variables of decreasing importance—first odour, then colour, then shape (Gould 1986). Both of these biases increase the likelihood that the learned behaviour will be adaptive—gastric illness is most likely caused by food, which is most reliably identified by taste and odour rather than shape and sound, while the hierarchy of flower characteristics also reflects decreasing reliability under natural conditions—odour is less variable and more reliable than colour, which may be affected by light conditions; both odour and colour are more reliable than shape, which may be affected by angle of approach, wind direction, flower damage etc.

These ideas have recently been elaborated upon in the context of *niche construction* (Odling Smee et al. 2003; Laland and Sterelny 2006), the process whereby organisms actively modify and generate their own and other organisms' environments, and hence also their own and other organisms' selection pressures. Familiar examples (of many: Odling Smee et al. 2003) include beavers building dams to alter river flow and create lakes, and earthworms changing the composition of soil to suit their freshwater-adapted physiology. Within the niche construction perspective, organisms take a more active role in directing their own and other organisms' (biological) evolution. For example, in discussing beavers' dam-building, Laland and Sterelny (2006) write of "the *active agency* of beavers in constructing these modified selection pressures and thereby acting as *codirectors* of their own evolution" (p. 1752, italics added). Laland et al. (2000) note that in many species the ontogenetic processes of individual and social learning can bias biological evolution in non-random directions, through the production of what they term 'smart variants,' such as the learning biases noted above. Jablonka and Lamb (2005) also discuss how behavioural inheritance, like other epigenetic forms of inheritance, can bias biological evolution in non-random directions. Similarly, West-Eberhard (2003) discusses how environmental conditions can directly induce adaptive changes in plastic phenotypes, and these adaptive plastic responses may be subsequently inherited either genetically or epigenetically.

Within the frameworks of niche construction, epigenetic inheritance and phenotypic plasticity, non-random, predictive biases take on much greater significance than in standard evolutionary theory, given that the biases are not only generated by, but also feed back into, the main genetic program, by directly altering the selection pressures of the niche constructing species and other species in the same ecosystem. In some cases this genetically-biased behavioural learning can, if repeated in successive generations, result in the learned behaviour coming under the complete control of the main genetic program,

¹ This does not imply that biological evolution is *always* biased in a biologically adaptive direction—the function of learning is to track environmental change that occurs *faster* than can be tracked by closed genetic programs, hence learning is always to some degree open and may take on biologically neutral or biologically maladaptive forms (Plotkin 1995).

independent of learning and its costs and uncertainties (Baldwin 1896; Sterelny 2004). The key point here is that behavioural learning, and other open teleonomic processes in biological evolution, allow natural selection to predict uncertain future conditions on the basis of reliable statistical regularities that occurred in the past. This ‘biological foresight’ is not the result of supernatural clairvoyance, and there is no guarantee that the predictions will be 100% accurate.

Biological foresight—Conclusions

Biological evolution is non-teleological, and is not guided by a supernaturally clairvoyant being or beings. Yet biological evolution exhibits what we may call ‘biological foresight’, in the form of adaptive mutation and behavioural smart variants. Hence foresight and blindness are not mutually exclusive: blind evolutionary processes may give rise to teleonomic mechanisms that exhibit some degree of foresight. So when critics contrast ‘blind biological evolution’ with ‘foresight-driven/goal-directed cultural evolution’, they are making a false contrast. The presence of non-randomness, goal-directedness or foresight in culture should not automatically invalidate a theory of Darwinian cultural evolution.

Evidence regarding foresight in human culture

While in the previous section it was shown that the mere presence of foresight does not invalidate a theory of Darwinian cultural evolution, this does not in itself demonstrate that the critics of cultural evolution are wrong. It may be that human foresight is so accurate and so influential in directing cultural change that all that would be needed to fully understand culture would be an understanding of people’s plans, goals and desires, consistent with non-Darwinian theories of culture. Novel cultural innovations generated by this perfect or near-perfect foresight would be immediately and perfectly adaptive; Darwinian selection processes would therefore have nothing to select, and cultural evolution would be an inappropriate model of cultural change. However, several lines of evidence suggest that this is not the case, by casting doubt on the accuracy and influence of foresight in culture.

The history and sociology of technological innovation and scientific discovery

Many historical case studies of innovation and discovery suggest that cultural change is less directed and guided by foresight than is commonly conceived. Simonton (1995) has documented how innovation or discovery is sometimes the result of blind trial and error, such as when Watson and Crick painstakingly tried to fit molecular models together until they hit on the double helix. While a great deal of prior work had gone into getting to, and constraining the possible results of, that trial and error stage, this parallels the teleonomic guided learning discussed above, in which behaviour is biased towards the random generation of adaptive/successful forms. Successful inventions or discoveries are also frequently the result of serendipity—unintended accidents or coincidences, which by definition preclude foresight—to which Simonton (1995) attributes the invention or discovery of, among other things, anaesthesia, electromagnetism, ozone, photography, dynamite, the gramophone, vaccination, saccharin, X-rays, radioactivity, classical

conditioning, penicillin, Teflon and Velcro. Similarly, sociological studies of scientific discovery, where working scientists are observed over extended periods of time and their methods carefully analysed, find that successful breakthroughs are frequently the result of unexpected findings (Dunbar 1995), which again are, by definition, unintended and not the product of foresight. In other cases the eventual use of an artifact or invention differs from the use intended or envisioned by the inventor, suggesting that foresight is less accurate and intent is less important than commonly assumed. For example, Basalla (1988, p. 139) notes that Thomas Edison originally intended his 1877 phonograph (record player) to be primarily a means of recording dictation in offices, and actively opposed its use for reproducing music, its eventual primary function. Other examples of inventions for which their inventors had demonstrably erroneous foresight include the tape recorder, radio, steam engines, computers and cameras (Basalla 1988). Basalla (1988) also provides a convincing case that, contrary to popular wisdom, ‘need’ does not always, or even often, drive cultural change (see also Petroski 1994; Ziman 2000; Wheeler et al. 2002), counting against a view of cultural change as being strongly directed towards solving a specific problem or fulfilling a specific need.

Other historical cases appear to demonstrate that a single inventor is indeed responsible for a major advance, and this inventor has seemingly intended to solve a specific problem or fulfil a specific need. As noted above, however, this may be analogous to biological foresight, where past events have biased evolution in a specific non-random direction that makes the emergence of successful innovations or behaviours more likely, and as such is perfectly consistent with a Darwinian approach to culture. An example again comes from Edison, who is a good candidate for a ‘great mind’ responsible for ‘great leaps’ in human culture. In a detailed and systematic study of Edison’s original notebooks, Carlson (2000) shows that Edison employed a small number of basic problem-solving ‘strategies’ or ‘heuristics’ that increased the likelihood of a successful innovation emerging, such as ‘simultaneously pursue multiple lines of investigation’ or ‘repeat components in multiple inventions’. Weber and Perkins (1989) similarly identify a small number of heuristics that lead to successful innovation, such as ‘change size/number of a component’ or ‘combine simpler inventions’, demonstrating how these simple heuristics can account for the cultural evolution of the knife from simple stone tool to Swiss Army knife. Dennett (2006) presents a similar argument that cultural change is frequently the result of higher-level semantic norms.

Bounded rationality and biased decision-making

Further evidence challenging the assumed accuracy of human foresight comes from the experimental literature on ‘bounded rationality’ (Simon 1982), which finds that people use ‘fast and frugal’ heuristics and biases to arrive at satisfactory but not necessarily optimal solutions to problems using as little processing and in as little time as possible (Tversky and Kahneman 1974; Todd and Gigerenzer 2001). Specifically relevant is work in experimental psychology and economics which demonstrates flaws in peoples’ foresight or planning. The ‘planning fallacy’ (Kahneman and Tversky 1979; Buehler et al. 1994) describes the common tendency for people to underestimate the time it would take them to complete tasks and to overly focus on optimistic scenarios to the exclusion of pessimistic ones. Irrational reasoning regarding future outcomes is also demonstrated by ‘hyperbolic discounting’ (Kirby 1997; Green and Myerson 2004), where people prefer small, immediate payoffs to larger, delayed payoffs, yet irrationally show the reverse preference when

the same two payoffs, separated by the same time gap, are both delayed. Finally, people may not engage in relatively costly individual learning at all, and blindly copy the behaviour, strategy or solution of another individual. Mathematical analyses find that conformity to a group majority (Boyd and Richerson 1985; Henrich and Boyd 1998) or copying a successful or prestigious individual (Boyd and Richerson 1985; Henrich and Gil White 2001) can, under a wide range of conditions, be more adaptive than costly individual learning, and a large body of experimental work in social psychology testifies to the strength and ubiquity of people's reliance on social learning (Asch 1951; Bandura 1977). In certain cases these biases may lead to the spread of maladaptive, non-optimal behaviour, and social learning biases generally stand in contrast to the near-perfect, rational process of deliberate, purposeful foresight assumed by critics of cultural evolution.

The experimental literature also suggests that problem-solving and creative thinking may be the result of systematic searches within problem-spaces, with that search guided or directed by specific problem-solving heuristics (Newell and Simon 1972). As in the historical studies discussed above, these guided searches can be seen as akin to the teleonomic behavioural biases that constitute biological foresight. Kaplan and Simon (1990), for example, found that when faced with a difficult problem, people employ a 'notice invariants' heuristic, where features of a problem that do not change as the situation changes attract particular attention. Other cultural biases might result from biological evolution, such as a bias for social information (Mesoudi et al. 2006b) that reflects past biological selection for social information processing (Dunbar 2003).

Mental time travel

It has recently been proposed that some instances of human foresight can be characterised as "mental time travel" (Atance and O'Neill 2001; Suddendorf and Corballis 2007). Mental time travel is defined as the faculty that allows humans to mentally project themselves backward in time to relive, or forward to prelive, events (Suddendorf and Corballis 2007). Mental time travel to the past describes episodic memory (Tulving 2002), while mental time travel to the future describes episodic foresight; both episodic memory and episodic foresight describe the same cognitive and neural system, but directed at different points in time (Suddendorf and Corballis 2007). Episodic foresight can be contrasted with the heuristics and biases described in the previous section, which are relatively fixed behavioural rules or scripts (Schank and Abelson 1977) resulting from specific past experiences, and which are more likely dependent on the semantic memory system. Unlike script-based foresight, episodic foresight is argued to involve the active and flexible simulation of future scenarios that may have no past precedent. Based on current evidence from comparative psychology, Suddendorf and Busby (2003) argue that mental time travel is not found in any species other than humans.

Does this capacity for mental time travel (or episodic foresight) invalidate a Darwinian theory of cultural evolution? It is certainly a more plausible argument than those we have encountered so far—if people can imagine future scenarios and anticipate future needs or desires, then they can purposively guide their actions towards future goals and desirable future scenarios. An understanding of these goals and desires would be sufficient for explaining and understanding culture; population-based evolutionary approaches and methods would be unnecessary. The fact that this capacity is only found in humans highlights the uniqueness of human culture, and lends credence to arguments against the use of evolutionary methods to study culture. There is also more of a disanalogy here with

biological evolution: biological evolution can prepare for future scenarios based on prior events, but cannot actively simulate future scenarios that have never happened before.

However, I believe these arguments to be at best premature. It is important to clarify that episodic foresight still does not equate to clairvoyance, because there is no guarantee that the future simulation will be accurate. In fact, mental time travel is likely to be an extremely complex and demanding task—you must simulate not only the physical aspects of a possible future scenario (one of many), but also simulate your future self, and how your future self would interact with that future scenario using possibly different beliefs, desires and knowledge to your current beliefs, desires and knowledge, *and* simulate the different beliefs, desires and knowledge of other people in that future scenario, and how they would react to your actions (and how you would react to their actions, and how they would change their actions in response to their anticipation of your reaction, and so on, with ever increasing complexity and levels of intentionality). Moreover, if mental time travel is an extension of episodic memory, then the extensive evidence that episodic memory is highly susceptible to numerous errors, biases and distortions (Loftus and Ketcham 1994; Loftus 1996) suggests that episodic foresight might be similarly flawed.

Human foresight—Conclusions

The evidence reviewed here suggests that cultural change is far less guided and directed, and human foresight far less perfect, than assumed by many critics of cultural evolution. Much cultural change does not appear to be influenced by foresight or planning, and where it is, this can be explained in terms of previously-acquired heuristics and strategies that bias cultural evolution in directions that are likely to result in successful innovations, paralleling the behavioural and genetic mechanisms that bias biological evolution in directions that are likely to be adaptive. The more active and flexible form of foresight recently labelled “mental time travel” also fails to invalidate the theory of cultural evolution, given that there is still no guarantee that this episodic foresight will be accurate enough to make selection redundant. In Dennett’s (1995) terms, foresight in cultural evolution is a crane (or a series of cranes, such as script-like heuristics and mental time travel), not a skyhook.

However, this conclusion should be qualified by acknowledging the shortcomings of the relevant data that are currently available. The problem with historical case studies such as those “reviewed above” is that they may be either consciously or unconsciously selected by the researcher to confirm a specific hypothesis, with other non-confirmatory cases selectively ignored. It would be useful to conduct a more systematic test of a collected database of inventions, discoveries and innovations from the history of science and technology, in order to more precisely quantify and measure the role of foresight in cultural change. We might also model cultural change using agents of varying degrees of foresight (from completely blind to clairvoyant) using agent-based modelling methods (Epstein and Axtell 1996; Kohler and Gumerman 2000), and match the resulting cultural dynamics to actual historical, sociological or archaeological data. However, the same criticism can be levelled at the critics of cultural evolution, who similarly appeal to anecdotes or intuition to argue that cultural change is directed in a non-Darwinian sense. More generally, the current debate in the cultural sciences, which often relies on intuition and anecdotes, stands in sharp contrast to the equivalent debate in biology, which, as we saw in the section “Adaptive mutation”, constitutes a body of rigorous experimental studies in which specific hypotheses are tested and theoretical tenets are continually challenged and refined,

resulting in a gradual refinement of theory and scientific progress. Cultural scientists would do well to imitate this ethos.

General conclusions

The simplistic dichotomy between ‘blind, undirected, random biological evolution’ and ‘foresight-driven, directed, non-random cultural evolution’ is untenable in the face of empirical evidence regarding both biological and cultural change, and provides no reason to reject a Darwinian theory of cultural evolution. In the section “Foresight vs. clairvoyance” it was argued that intuitive appeals to such a dichotomy often falsely conflate clairvoyance and foresight. These are not equivalent, given that people cannot foresee the future with 100% accuracy. The mere presence of foresight (non-supernatural predictions regarding future events) does not invalidate a Darwinian theory of cultural evolution, given that foresight may evolve through a past process of blind evolution. This is demonstrated by the examples of foresight in biological evolution that were discussed in the section “Biological foresight”: genetically-specified biases may guide behavioural learning in adaptive directions, organisms may actively modify their own selection pressures as part of their niche constructing activities, and adaptive, non-random biases in genetic mechanisms may increase the likelihood of a favourable mutation arising. In section “Evidence regarding foresight in human culture” reviewed evidence from the social sciences which suggests that people are far from clairvoyant and their foresight is far from perfect: scientific and technological change is often the result of serendipity and seldom proceeds according to the intentions of individual inventors or scientists, while experimental evidence suggests that various cognitive biases cause people to overestimate the efficacy of their future behaviour and underestimate future rewards. All of this evidence suggests that the difference between biological and cultural change in terms of foresight is less pronounced than critics commonly claim.

It is also important to note that evolutionary methods originally developed by biologists to study biological evolution have been, and are being, productively applied to specific cases of cultural change, such as phylogenetic methods (Mace and Pagel 1994; O’Brien and Lyman 2003; Mace and Holden 2005; Lipo et al. 2006) and population genetic models (Cavalli-Sforza and Feldman 1981; Boyd and Richerson 1985; Laland et al. 1995; McElreath and Henrich 2006). If the critics are correct that cultural change is non-Darwinian because of the presence of foresight, then it surely should not be possible to successfully apply Darwinian evolutionary methods, originally designed to analyse biological phenomena (which, the critics argue, lack foresight), to culture. This is not to say that all of this work is perfect, or that such methods can be used to analyse *all* cultural phenomena, but it moves the burden of proof to the critics, who must specify exactly *how* foresight invalidates these specific methods.

The presence of foresight, while not invalidating a Darwinian theory of cultural evolution, does have important implications for how culture should be studied using Darwinian methods. The psychological theory and data discussed in the section “Evidence regarding foresight in human culture” need to be explicitly incorporated into Darwinian models and methods, in order to delineate exactly how such processes might affect cultural change. Mathematical models and experimental simulations can be used to analyse such processes and the results of such models or simulations can be tested against actual historical, archaeological and sociological data. Researchers might try to determine to what extent cultural change can be explained assuming script-based foresight (based on

script-like behavioural expectancies) versus episodic foresight (involving mental simulation of novel future scenarios). Some historical case studies have already informally identified the operation of script-like heuristics (e.g. Carlson 2000). Experimental laboratory simulations of cultural microevolution (Mesoudi 2007) might identify potential signatures of episodic foresight, and consequently allow anthropologists, archaeologists, sociologists and historians to look for such a signature in actual cultural evolution.

Part of the problem lies in the strong division between, on the one hand, cultural anthropology, sociology and the other social sciences traditionally responsible for studying culture, and, on the other hand, the psychological and behavioural sciences. This division insulates the former disciplines from the work emerging in the latter, such as heuristics and biases or mental time travel, which, “as discussed above”, is potentially highly relevant to their subject matter—culture. Unfortunately, many cultural scientists still harbour invalid dualist or outmoded (e.g. Freudian: Paul 1989) theories of human cognition. Ironically, the very theory that many cultural anthropologists oppose—Darwin’s theory of evolution—provided a synthetic framework that unified the biological sciences, and the resulting cross-disciplinary integration partly led to the phenomenal success of biology during the 150 years since Darwin wrote *The Origin* (Mayr 1982b). As argued by Mesoudi et al. (2006a), Darwin’s theory of evolution can facilitate a similar synthesis for a unified science of culture, and, as hopefully shown here, arguments concerning foresight as yet offer no substantive opposition to this synthesis.

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References

- Asch SE (1951) Effects of group pressure on the modification and distortion of judgments. In: Guetzkow H (ed) *Groups, leadership and men*. Carnegie, Pittsburgh, PA, pp 177–190
- Atance CM, O’Neill DK (2001) Episodic future thinking. *Trends Cogn Sci* 5:533–539
- Baldwin JM (1896) A new factor in evolution. *Am Nat* 30:441–451
- Bandura A (1977) *Social learning theory*. Prentice-Hall, Oxford
- Basalla G (1988) *The evolution of technology*. Cambridge University Press, Cambridge
- Benton T (2000) Social causes and natural relations. In: Rose H, Rose S (eds) *Alas, Poor Darwin*. Harmony, New York, pp 206–224
- Boyd R, Richerson PJ (1985) *Culture and the evolutionary process*. University of Chicago Press, Chicago
- Bryant JM (2004) An evolutionary social science? A skeptic’s brief, theoretical and substantive. *Philos Soc Sci* 34:451–492
- Buehler R, Griffin D, Ross M (1994) Exploring the planning fallacy: why people underestimate their task completion times. *J Personal Soc Psychol* 67:366–381
- Campbell DT (1974) Evolutionary epistemology. In: Schilpp PA (ed) *The philosophy of Karl Popper*. Open Court, La Salle, IL, pp 413–463
- Carlson WB (2000) Invention and evolution: the case of Edison’s sketches of the telephone. In: Ziman J (ed) *Technological innovation as an evolutionary process*. Cambridge University Press, Cambridge, pp 137–158
- Carneiro RL (1985) Comment on Darwinian selection, symbolic variation, and the evolution of culture by D. Rindos. *Curr Anthropol* 26:77–78
- Cavalli-Sforza LL, Feldman MW (1981) *Cultural transmission and evolution*. Princeton University Press, Princeton
- Chater N (2005) Mendelian and Darwinian views of memes and cultural change. In: Hurley S, Chater N (eds) *Perspectives on imitation*, vol 2. MIT Press, Cambridge, MA, pp 355–362
- Darwin C (1859/1968) *The origin of species*. Penguin, London
- Darwin C (1871/2003) *The descent of man*. Gibson Square, London
- Dasgupta S (2004) Is creativity a Darwinian process? *Creat Res J* 16:403–413

- Dawkins R (1996) *The blind watchmaker*. W.W. Norton, New York
- Dennett D (1995) *Darwin's dangerous idea*. Simon & Schuster, New York
- Dennett D (2006) From typo to thinko: when evolution graduated to semantic norms. In: Levinson SC, Jaisson P (eds) *Evolution and culture*. MIT Press, Cambridge, MA
- Dunbar K (1995) How scientists really reason. In: Sternberg RJ, Davidson J (eds) *Mechanisms of insight*. MIT Press, Cambridge MA, pp 365–395
- Dunbar RIM (2003) The social brain. *Ann Rev Anthropol* 32:163–181
- Epstein JM, Axtell R (1996) *Growing artificial societies*. MIT Press, Cambridge, MA
- Foster PL (2004) Adaptive mutation in *Escherichia coli*. *J Bacteriol* 186:4846–4852
- Garcia J, Kimeldorf DJ, Koelling RA (1955) Conditioned aversion to saccharin resulting from exposure to gamma radiation. *Science* 122:157–158
- Gould JL (1986) The biology of learning. *Ann Rev Psychol* 37:163–192
- Green L, Myerson J (2004) A discounting framework for choice with delayed and probabilistic rewards. *Psychol Bull* 130:769–792
- Hallpike CR (1986) *The principles of social evolution*. Clarendon Press, Oxford
- Henrich J, Boyd R (1998) The evolution of conformist transmission and the emergence of between-group differences. *Evol Human Behav* 19:215–241
- Henrich J, Gil White FJ (2001) The evolution of prestige. *Evol Human Behav* 22:165–196
- Henrich J, Boyd R, Richerson PJ Five misunderstandings about cultural evolution. *Hum Nature* (forthcoming)
- Jablonka E, Lamb MJ (2005) *Evolution in four dimensions*. MIT Press, Cambridge, MA
- James W (1880) Great men, great thoughts, and the environment. *Atl Mon* 46:441–459
- Kahneman D, Tversky A (1979) Intuitive prediction: biases and corrective procedures. *TIMS Stud Manage Sci* 12:313–327
- Kaplan CA, Simon HA (1990) In search of insight. *Cogn Psychol* 22:374–419
- Kirby KN (1997) Bidding on the future: evidence against normative discounting of delayed rewards. *J Exp Psychol Gen* 126:54–70
- Köhler TA, Gummerman GJ (eds) (2000) *Dynamics in human and primate societies*. Oxford University Press, New York, NY
- Laland KN, Sterelny K (2006) Seven reasons (not) to neglect niche construction. *Evolution* 60:1751–1762
- Laland KN, Kumm J, Feldman MW (1995) Gene-culture coevolutionary theory—a test-case. *Curr Anthropol* 36:131–156
- Laland KN, Odling Smee J, Feldman MW (2000) Niche construction, biological evolution, and cultural change. *Behav Brain Sci* 23:131–175
- Layton JC, Foster PL (2003) Error-prone DNA polymerase IV is controlled by the stress-response sigma factor, Rpos, in *Escherichia coli*. *Mol Microbiol* 50:549–561
- Lipo CP, O'Brien MJ, Collard M, Shennan S (eds) (2006) *Mapping our ancestors: phylogenetic approaches in anthropology and prehistory*. Aldine, New York
- Loftus EF (1996) *Eyewitness testimony*. Harvard University Press, Cambridge, MA
- Loftus EF, Ketcham K (1994) *The myth of repressed memory*. St Martin's, New York
- Lorenz K (1969) Innate bases of learning. In: Pribram K (ed) *On the biology of learning*. Harcourt, New York, pp 13–91
- Luria SE, Delbrück M (1943) Mutations of bacteria from virus sensitivity to virus resistance. *Genetics* 28:491–511
- Mace R, Holden CJ (2005) A phylogenetic approach to cultural evolution. *Trends Ecol & Evol* 20:116–121
- Mace R, Pagel MD (1994) The comparative method in anthropology. *Curr Anthropol* 35:549–564
- Mayr E (1982a) Teleological and teleonomic: a new analysis. In: Plotkin H (ed) *Learning, development and culture*. John Wiley, Chichester, pp 17–38
- Mayr E (1982b) *The growth of biological thought*. Harvard University Press, Cambridge, MA
- McElreath R, Henrich J (2006) Modeling cultural evolution. In: Dunbar RIM, Barrett L (eds) *Oxford handbook of evolutionary psychology*. Oxford University Press, Oxford
- Mesoudi A (2007) Using the methods of social psychology to study cultural evolution. *J Soc Evol Cult Psychol* 1:35–58
- Mesoudi A, Whiten A, Laland KN (2004) Is human cultural evolution Darwinian? Evidence reviewed from the perspective of *the origin of species*. *Evolution* 58:1–11
- Mesoudi A, Whiten A, Laland KN (2006a) Towards a unified science of cultural evolution. *Behav Brain Sci* 29:329–383
- Mesoudi A, Whiten A, Dunbar RIM (2006b) A bias for social information in human cultural transmission. *Br J Psychol* 97:405–423
- Morgan LH (1877) *Ancient society*. Henry Holt, New York

- Müller M (1870) The science of language. *Nature* 1:256–259
- Newell A, Simon HA (1972) Human problem solving. Prentice-Hall, Englewood Cliffs, NJ
- O'Brien MJ, Lyman RL (2003) Cladistics and archaeology. University of Utah Press, Salt Lake City
- Odling Smee FJ, Laland KN, Feldman M (2003) Niche construction: the neglected process in evolution. Princeton University Press, Princeton, NJ
- Paul RA (1989) Psychoanalytic anthropology. *Ann Rev Anthropol* 18:177–202
- Petroski H (1994) The evolution of useful things. Vintage, New York
- Pitt-Rivers AL (1875) On the evolution of culture. *J Anthropol Inst* 4:293–308
- Plotkin H (1995) Darwin machines and the nature of knowledge. Penguin, London
- Richerson PJ, Boyd R (2005) Not by genes alone. University of Chicago Press, Chicago
- Rosenberg SM (2001) Evolving responsively: adaptive mutation. *Nat Rev Genet* 2:504–515
- Sahlins M, Service E (1960) Evolution and culture. Ann Arbor, Michigan
- Schank RC, Abelson RP (1977) Scripts, plans, goals and understanding. Lawrence Erlbaum, Oxford
- Seligman MEP (1970) On the generality of the laws of learning. *Psychol Rev* 77:406–418
- Simon HA (1982) Models of bounded rationality. MIT Press, Cambridge, MA
- Simonton DK (1995) Foresight in insight? A Darwinian answer. In: Sternberg RJ (ed) The nature of insight. MIT Press, Cambridge, MA, pp 465–494
- Spencer H (1896) The principles of sociology. Appleton, New York
- Sterelny K (2004) A review of evolution and learning: the Baldwin effect reconsidered, edited by B. Weber, D. Depew. *Evol & Develop* 6:295–300
- Sternberg RJ (1999) Darwinian creativity as a conventional religious faith. *Psychol Inq* 10:357–359
- Suddendorf T, Busby J (2003) Mental time travel in animals? *Trends Cogn Sci* 7:391–396
- Suddendorf T, Corballis MC (2007) The evolution of foresight: what is mental time travel and is it unique to humans? *Behav Brain Sci* 30
- Todd PM, Gigerenzer G (2001) Précis of simple heuristics that make us smart. *Behav Brain Sci* 23:727–741
- Tulving E (2002) Episodic memory. *Ann Rev Psychol* 53:1–25
- Tversky A, Kahneman D (1974) Judgment under uncertainty: heuristics and biases. *Science* 185:1124–1131
- Tylor EB (1871) Primitive culture. John Murray, London
- Weber RJ, Perkins DN (1989) How to invent artifacts and ideas. *New Ideas Psychol* 7:49–72
- West-Eberhard MJ (2003) Developmental plasticity and evolution. Oxford University Press, Oxford
- Wheeler M, Ziman J, Boden MA (eds) (2002) The evolution of cultural entities. Oxford University Press, Oxford
- White L (1959) The evolution of culture. McGraw-Hill, New York
- Ziman J (ed) (2000) Technological innovation as an evolutionary process. Cambridge University Press, Cambridge