Evolutionary Synthesis in the Social Sciences and Humanities

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ABSTRACT

Cultural change constitutes a Darwinian evolutionary process, comprising the three Darwinian principles of variation, selection and inheritance. Yet cultural evolution is not identical to genetic evolution: the sources of variation, the forms of selection and the modes of inheritance found in cultural evolution may be very different to those found in genetic evolution. Here, I review research conducted in the last 30 years that has built a Darwinian theory of cultural change by borrowing the rigorous, quantitative methods developed by biologists to explain biological evolution, yet simultaneously acknowledging the differences between cultural and genetic evolution. I argue that the quantitative nature of Darwinian methods (e.g. statistical analysis, formal models, laboratory experiments) has resulted in a significantly better understanding of cultural phenomena than many traditional non-evolutionary, non-scientific approaches to cultural change in the social sciences and humanities. Evolutionary theory also provides a synthetic framework within which different branches of the social sciences and humanities may be integrated, equivalent to the "evolutionary synthesis" that integrated the biological sciences in the early 20th century.

WHAT FORM SHOULD A "CULTURAL SCIENCE" TAKE? In this paper I argue that a large body of research already exists that uses quantitative, scientific methods to explain cultural phenomena, and which provides a productive alternative to the non-scientific, post-modernist approach that has taken hold in many branches of the social sciences and humanities (SSH). This research takes as its starting point the observation that cultural change constitutes a Darwinian evolutionary process that shares fundamental similarities with biological/genetic evolution, yet also exhibits important differences to genetic evolution. As well as providing a set of useful, quantitative methods for studying culture, viewing culture as an evolutionary process also encourages interdisciplinary synthesis within the traditionally fractionated SSH, linking micro-level disciplines (e.g. psychology, micro-economics) to macro-level disciplines (e.g. archaeology, anthropology, historical linguistics, macroeconomics). First, I specify exactly what it means to say that culture constitutes a Darwinian evolutionary process.

Culture evolves

At its most basic, Darwin's theory of evolution comprises three principles, or preconditions (Darwin, 1859; Lewontin, 1970): variation, selection (or what Darwin called a "struggle for existence") and inheritance. Indeed, The Origin of Species was essentially a catalogue of evidence demonstrating that these three principles apply to populations of biological organisms. Thus Darwin showed that organisms within a species/population vary in their characteristics (wing span, beak shape etc.) rather than constituting unvarying Platonic types; that the Malthusian rate at which populations of organisms grow inevitably results in competition over resources (food, nesting space, mates etc.) such that not all organisms will be equally likely to survive and reproduce; and that offspring inherit characteristics from their parents, such that offspring resemble their parents more than a randomly chosen organism. Combined, these principles form Darwin's theory of evolution: characteristics that allow an organism to better survive and/or reproduce will be more likely to get passed on to offspring, and these characteristics will increase in frequency.

Note that Darwin knew nothing of the genetic basis of inheritance (which was being determined around the same time but entirely independently by Gregor Mendel), of the sources of variation such as genetic mutation and recombination, or various other details concerning how variation arises, how selection operates, and how traits are inherited. Indeed, several of his working assumptions turned out to be dead wrong. He believed, for example, that biological inheritance was Lamarckian, i.e. that changes to organisms during their lifetimes, such as the lengthening of muscles due to extended use, were directly transmitted to offspring through the germ-line. Experimental geneticists such as August Weismann later showed that acquired characteristics are not directly transmitted to offspring, and that there is a strict separation of genotype (germline) and phenotype (soma). Darwin also incorrectly believed that traits may blend during inheritance; one of Mendel's key discoveries was that traits (later named genes) do not blend, they are inherited in a particulate, all-or-nothing fashion.

If "Darwinian evolution" is defined in this minimal way as a system of variation, selection and inheritance, irrespective of the details of how these principles operate, then I think it is uncontroversial to argue that culture constitutes a Darwinian evolutionary process (Mesoudi, forthcoming; Mesoudi, Whiten, & Laland, 2004). Abundant evidence exists that cultural traits vary, and often enormously: there are 7000 languages spoken in the world, 10,000 religious denominations practiced, 7.7 million US patents issued, 3 million Wikipedia pages written, and so on. Constraints on attention, memory and time necessitate some kind of selection process acting on this variation: no single person could learn how to speak 7000 languages or how to make 7.7 million technological inventions, and it is extremely difficult to be both a Christian and a Muslim at the same time. And it is also uncontroversial to assume that this variation in languages, beliefs, knowledge and so on is inherited not genetically but culturally, i.e. via social learning mechanisms such as imitation, or spoken or written language. In sum, culture exhibits variation, selection and inheritance, therefore culture evolves according to Darwinian principles.

This is not a novel claim by any means. Darwin himself wrote in *The Descent of Man* that his theory of evolution applied not only to biological change but also to cultural change, specifically linguistic change:

> The formation of different languages and of distinct species, and the proofs that both have been developed through a gradual process, are curiously parallel…The survival or preservation of certain favoured words in the struggle for existence is natural selection (Darwin, 1871; 90-91)

Over the next few decades, a string of highly reputable anthropologists (Morgan, 1877; Tylor, 1871), sociologists (Keller, 1915; Spencer, 1896), psychologists (Baldwin, 1909; James, 1880), economists (Veblen, 1898), linguists (Muller, 1870; Schleicher, 1863) and archaeologists (Pitt-Rivers, 1875) similarly argued that Darwin's theory could be applied to the particular cultural phenomena studied within their discipline. Yet the SSH today exhibit little influence of this early interest in cultural evolution. Indeed, it is fair to say that an evolutionary approach to cultural change is viewed with suspicion or downright hostility within the SSH. While there are many historical reasons for this rejection (Mesoudi, Veldhuis, & Foley, 2010), such as an unfounded association of cultural evolution with eugenics and social Darwinism (Hodgson, 2004) and the unfortunate post-modern, anti-scientific turn in many branches of the SSH (Slingerland, 2008), I think that at least some of the blame lies with early theories of cultural evolution themselves. In the next section I examine two particularly prominent but, in my view, flawed theories of cultural evolution, before in the following section turning to a more productive theory of cultural evolution.

Inadequate theories of cultural evolution

Many of the early theories of cultural evolution proposed within sociology and anthropology were not, in fact, very Darwinian. The cultural evolutionary theories of Tylor (1871) and Morgan (1877) were based instead on Herbert Spencer's progressive notion of evolution, where species progress along a sequence of fixed and unitary stages of increasing complexity, from simple unicellular organisms to vertebrates and ultimately humans. Such a progressive, ladder-like view of evolution is thoroughly rejected by contemporary biologists, and is very different to Darwin's theory: where Spencer saw a ladder, Darwin saw a branching tree; where Spencer saw abrupt change along fixed, unitary stages, Darwin saw variation within a gradually changing population. Unfortunately Tylor, Morgan and others applied Spencer's theory to cultural change, coming up with scientifically dubious and politically influenced stages of cultural evolution such as Savagery, Barbarism and Civilisation (with Victorian England at the top of the ladder). As subsequent anthropologists such as Boas (1920) demonstrated, there is no evidence for the existence of such fixed, unitary stages. Moreover, these Spencerian theories lacked any kind of mechanism for change: societies somehow magically jumped from one stage to another once they had reached the designated "complexity". It should be emphasised that these Spencerian theories of cultural evolution are very different to the Darwinian theory of cultural evolution of the kind outlined in the next section.

A second flawed theory of cultural evolution that has emerged more recently is memetics. In *The Selfish Gene*, Richard Dawkins (1976) coined the term "meme" to describe the

cultural equivalent of a gene, arguing that cultural change can be thought of as the differential replication of alternative memes. This idea has since been propounded by scholars such as Blackmore (1999) and Dennett (1995). The problem with memetics is that it makes too restrictive assumptions regarding the details of cultural evolution. As previously noted, a Darwinian theory of cultural evolution simply requires the existence of variation, selection, and inheritance, making no further assumptions regarding where the variation comes from, how selection operates and how traits are inherited. Memetics, in contrast, applies neo-Darwinian assumptions to cultural change, requiring that cultural variation be divided up into discrete units that are inherited in an all-or-nothing fashion, that cultural inheritance is non-Lamarckian, that cultural variation is generated in blindly (i.e. random with respect to utility), and so on. To most social scientists, these assumptions seem highly unrealistic: inventors, scientists and politicians often direct cultural change in specific directions rather than blindly applying principles or theories at random; traits (e.g. phonemes) blend when they are transmitted rather than transmitted in an all-or-nothing particulate fashion; people modify beliefs, ideas, technologies etc. before passing them on to someone else in a manner that resembles Lamarckian inheritance of acquired characteristics, and so on (Henrich, Boyd, & Richerson, 2008; Mesoudi, forthcoming). Memetics simply does not adequately recognise the differences between cultural and genetic evolution in a way that makes the memetics approach empirically useful. The fact that memetics has been restricted to writings in popular science books rather than empirical research may be testament to this shortcoming.

A truly Darwinian theory of cultural evolution

In my view, an adequate theory of cultural evolution, one that maintains Darwin's fundamental insight that change occurs when varying entities within a population are differentially inherited over successive generations, yet simultaneously acknowledges the differences in detail between genetic and cultural evolution, did not appear until the 1980s in the work of Cavalli-Sforza and Feldman (1981) and Boyd and Richerson (1985). Where previous theories of cultural evolution tended to the informal and speculative (Campbell, 1965; Dawkins, 1976), these pairs of researchers constructed formal, quantitative models of cultural evolution using mathematical modelling techniques devised by population geneticists to model genetic evolution. These models specify a set of varying cultural traits that are transmitted from generation to generation (or individual to individual within the same generation), specify a set of processes that act to make certain traits more or less likely to be transmitted, and determine the long-term dynamics of the resulting system, such as whether one trait drives all other traits to extinction or whether multiple traits co-exist in equilibrium, or whether some processes generate faster cultural change than other processes. Processes modelled by Cavalli-Sforza and Feldman (1981) and Boyd and Richerson (1985) include different modes of cultural transmission (vertical transmission from parent to offspring, oblique transmission from parental generation to a non-relative of the next generation, or horizontal transmission within the same generation); the consequences of blending cultural inheritance and non-discrete (i.e. non-meme-like) cultural variation; random cultural mutation (akin to genetic mutation) versus directed "guided variation", where people acquire traits, modify them, and pass them on in a manner that can be described as Lamarckian; content biases, where certain kinds of traits are intrinsically more memorable or cognitively attractive than others; frequency-

dependent biases, where traits are preferentially adopted if they are popular (conformity) or rare (anti-conformity); and model-based biases, where traits are preferentially adopted if they are exhibited by particularly successful or prestigious people.

Note that many of these processes are explicitly different to the genetic case, such as Lamarckian-like guided variation, blending inheritance, and biases such as conformity and prestige bias. Indeed, many of these processes are already well-established and well-studied within the mainstream, non-evolutionary SSH. Frequency-dependent (e.g. conformist) and model-based (e.g. prestige) biases, for example, have been studied for decades within social psychology (Mesoudi, 2009). Yet the real advantage of placing such processes within a Darwinian framework is that these individual-level processes can be explicitly and quantitatively linked to population-level cultural change. In other words, Darwinian methods solve the perennial "micro-macro" problem that pervades the SSH by explaining macro-level, population-level patterns in terms of the aforementioned micro-level, individual-level processes. I will illustrate this with an example.

An example: prehistoric projectile point evolution

The value of Darwinian methods is illustrated in a study by two archaeologists, Bettinger and Eerkens (1999), concerning cultural variation in prehistoric projectile points (arrowheads) from A.D. 300-600 from the Great Basin region of the south-western United States. Bettinger and Eerkens (1999) documented a curious difference between points found in two different regions of the Great Basin. Points found in central Nevada tended to be uniform in their designs, with tight linkage between the dimensions of the points, and consequently high correlations between dimensions (Figure 1). For example, long points are always thin, and short points are always thick, such that length and thickness tend to correlate across the region. Bettinger and Eerkens (1999) argued that this uniformity may have arisen through success-biased (a.k.a. "indirectly" biased) cultural transmission, where hunters within a group all copy the same most-successful hunter's arrowhead design. As hunters copy point designs as a complete package from a single model, dimensions across the group become linked and uniform, generating high correlations between dimensions (Figure 2).

		Width	Thickness	Weight
Max. length	NV	0.48*	0.51*	0.86
	CA	0.07	0.15	0.76
Width	NV		0.21	0.80*
	CA		0.05	0.14
Thickness	NV			0.70
	CA			0.57

Figure 1
Correlations between arrowhead dimensions in prehistoric Nevada (NV) and California (CA) as documented by Bettinger and Eerkens (1999). * indicates significantly higher correlation in NV compared to CA.
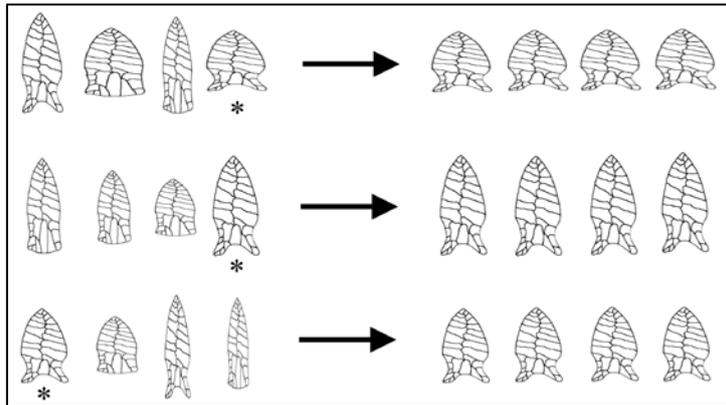
Figure 2

Bettinger and Eerkens' (1999) hypothesised explanation for highly correlated arrowhead dimensions in prehistoric Nevada in terms of success-bias. The left hand side shows arrowhead designs in three groups, with the asterisked design exhibited by the most successful hunter. Success-biased cultural transmission causes other group members to copy that single successful hunter's design, resulting on the right-hand side in uniformity within groups and correlations between dimensions across the entire region.

In contrast, points found in eastern California tend to be diverse in their designs, with no linkage between dimensions and low correlations between dimensions (Figure 1). Long points are no more likely to be thin than thick, such that dimensions show low correlations across the region. Bettinger and Eerkens (1999) argued that this pattern arose because point designs spread in this region via guided variation, where hunters copy a design and then modify it according to individual, trial-and-error learning. This latter individual modification would break down correlations between point dimensions (Figure 3).
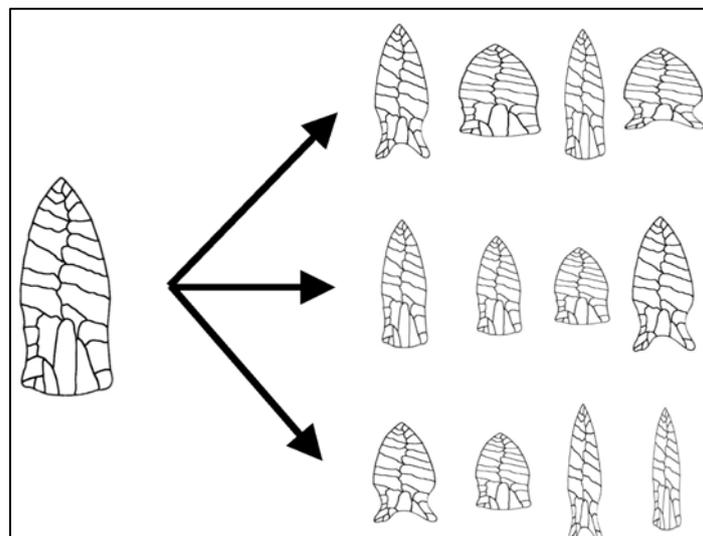

Figure 3

Bettinger and Eerkens' (1999) hypothesised explanation for poorly correlated arrowhead dimensions in prehistoric California in terms of guided variation. The single arrowhead on the left hand side is independently modified by each hunter, resulting in the diverse designs on the right hand side, with low correlations between dimensions across the region.

What Bettinger and Eerkens (1999) did in this study, then, was to explain population-level patterns in the archaeological record (high vs. low correlations between point dimensions) in terms of individual-level cultural transmission biases (success-bias vs. guided variation). However, given that we cannot go back and directly observe prehistoric hunters copying successful individuals or employing guided variation, Bettinger and Eerkens' hypothesis is still necessarily indirect. To address this problem, Michael O'Brien and I subsequently carried out a series of experimental (Mesoudi, 2008; Mesoudi & O'Brien, 2008a) and theoretical (Mesoudi & O'Brien, 2008b) simulations aiming to test whether Bettinger and Eerkens' hypothesised scenario really does generate the observed archaeological patterns. Participants in the lab, and computer-generated agents modelled on those participants' behaviour, designed "virtual arrowheads" via a simple computer game (Figure 4). We manipulated the transmission biases that participants/agents could employ, allowing them to either engage in individual trial-and-error learning (simulating guided variation) or copy other players in their group given information about their success in the game (allowing success-biased cultural transmission).
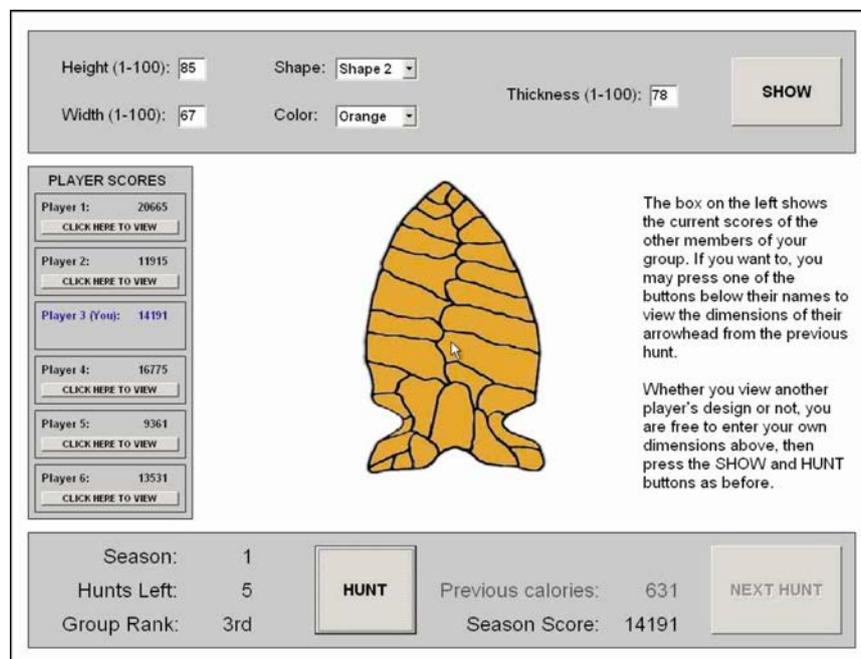

Figure 4
The virtual arrowhead task that participants played in Mesoudi and O'Brien (2008a).Participants could directly modify arrowhead dimensions via the boxes at the top (Height, Width etc.) allowing guided variation, or copy another participant via the panel on the left, allowing success-biased cultural transmission.

As predicted, success bias generated higher inter-arrowhead correlations than guided variation (Figure 5). The experimental simulation therefore supports Bettinger and Eerkens' (1999) hypothesised link between transmission biases and population-level artefact diversity. However, the observed correlations only occurred under certain conditions. In particular, the effect was only observed if we assumed multiple locally-optimal arrowhead designs. This is important because, if there is just a single globally-optimal (best-possible) design, then individual learners employing guided variation will independently converge on this single optimal design, and diversity will drop. If, on the

other hand, there are multiple locally optimal designs, then different hunters may converge on different locally optimal designs, generating the low correlations shown in Figure 5 and, by inference, the low correlations in prehistoric California documented by Bettinger and Eerkens (1999) (Figure 1). This shows how experiments can be used to directly test archaeological hypotheses that are intrinsically indirect, given the limitations of historical methods.

		Width	Thickness	Shape	Color
Height	Success bias	0.801***	0.996***	1.000***	0.828***
	Guided variation	0.272*	0.004	0.248	0.187
	Width	Success bias	0.752***	0.856***	0.994***
		Guided variation	0.014	0.300	0.350*
		Thickness	Success bias	0.895***	0.706***
			Guided variation	0.162	0.190
			Shape	Success bias	0.603***
				Guided variation	0.130

Figure 5

Correlations between virtual arrowhead dimensions in the experiment of Mesoudi & O'Brien (2008a), following success bias and guided variation. *** indicates a significant correlation at p<0.001.

Towards an interdisciplinary, evolutionary synthesis

The aforementioned example is but a first step in explaining cultural phenomena in terms of quantitatively-derived individual-level processes. It can be added to a growing number of studies that have the same aim, such as Henrich's (2001) explanation of the S-shaped curve that typically describes the diffusion of novel innovations in terms of conformist and content-biased cultural transmission (rather than guided variation), or Bentley et al.'s (2004) explanation of the distribution of first names, pottery decorations, patent citations and dog breed popularity in terms of random copying. Experimental studies are beginning to determine exactly what form "content-biased" cultural transmission takes, revealing biases for information concerning social interactions (Mesoudi, Whiten, & Dunbar, 2006), emotionally salient information (Heath, Bell, & Sternberg, 2001) and supernatural concepts that violate our intuitive folk beliefs (Barrett & Nyhof, 2001). Evolutionary economists are building on initial foundations (Nelson & Winter, 1982) to explain economic systems not in terms of static equilibria but in terms of dynamic, evolutionary processes (Dopfer & Potts, 2008; Hodgson & Knudsen, 2010). And finally, phylogenetic methods are being used to reconstruct the (macro-) evolutionary history of cultural traits, from languages (Gray & Jordan, 2000; Pagel, 2009) to written manuscripts (Howe et al., 2001) to artefacts in the archaeological record (O'Brien, Darwent, & Lyman, 2001; O'Brien & Lyman, 2003) to practices such as inheritance and marriage customs in the ethnographic record (Fortunato, Holden, & Mace, 2006; Holden & Mace, 2003).

I see all of this work as indicative of a potential "evolutionary synthesis" for the SSH (Mesoudi, 2007, forthcoming; Mesoudi, Whiten, & Laland, 2006). In the biological sciences, Darwin's theory of evolution resulted in the 1930s and 1940s in the hugely

productive integration of different hitherto-separate branches of biology (zoology, botany, anatomy, palaeontology, systematics, population genetics etc.), with each discipline studying different aspects of the same phenomena within the same theoretical framework (Huxley, 1942; Mayr & Provine, 1980). In contrast, the SSH today remain fractionated in different disciplines with often mutually exclusive theoretical assumptions and little exchange of theories, concepts, methods and findings across disciplinary boundaries. The work outlined above, in contrast, spans multiple traditional SSH disciplines, from anthropology to psychology to linguistics to economics. This may be because the Darwinian methods employed by Cavalli-Sforza and Feldman (1981), Boyd and Richerson (1985) and others are specifically designed to link micro-evolutionary processes to macro-evolutionary patterns. In biology, the micro-evolutionary processes are natural selection, genetic mutation and recombination, particulate inheritance and so on. In culture, the micro-evolutionary processes are guided variation, conformity, prestige bias, content biases, and so on. Yet the underlying logic is the same: macro-evolutionary patterns, from S-shaped innovation diffusion curves to regional differences in projectile point diversity to the distribution of first names or dog breeds, can be explained in terms of precisely-defined individual-level processes.

Figure 6 shows a potential structure of a synthetic evolutionary science of culture, with different branches of the SSH mapped onto those branches of the biological sciences that have the same aims and methods. There are two advantages of such a mapping scheme. First, we can borrow methods from the biological side and apply them to similar problems on the cultural side. The population-genetic-style mathematical modelling techniques used by Cavalli-Sforza and Feldman (1981) and Boyd and Richerson (1985) are an example of this, as are phylogenetic methods. (Note that this does not have to be a one-way street, and methods used in the SSH may also be borrowed by biologists: for example, biologists famously borrowed game theoretic methods from economists to analyse strategic interactions between organisms, and to great effect.)
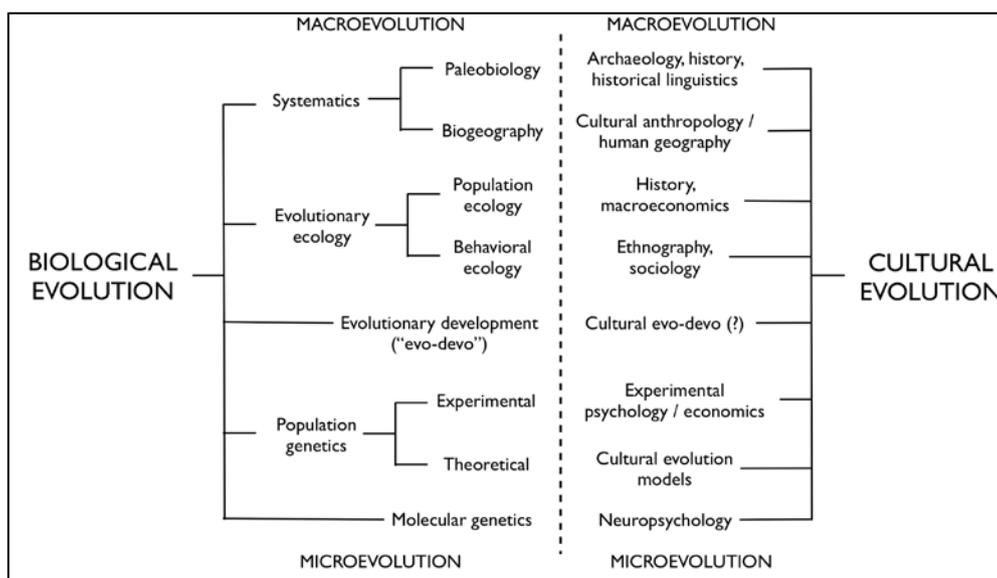

Figure 6

The structure of the biological sciences following the evolutionary synthesis (left-hand side) alongside an equivalent structure for an evolutionary cultural science (right-hand side). See Mesoudi et al. (2006) and Mesoudi (forthcoming) for details.

The second advantage of such an overarching evolutionary framework is that it encourages interaction between different branches of the SSH. More concretely, multiple methods can be used to address the same problem, and these methods frequently complement each other's strengths and weaknesses. This can be seen in the example discussed above: archaeologists such as Bettinger and Eerkens (1999) cannot go back in time and directly observe prehistoric hunters copying successful hunters or employing guided variation; any explanation of population-level differences in artefact variation must necessarily be indirect. Yet with experimental simulations, such as the one conducted by Mesoudi and O'Brien (2008a), we can directly observe people copying others, as well as manipulate how they learn and manipulate variables such as fitness functions and learning costs, in order to more powerfully test hypotheses than is possible with purely historical methods. In other words, experiments offer greater "internal validity", or the ability to test causal hypotheses. Of course, with experiments there is a corresponding drop in "external validity", or the extent to which the experiment successfully captures the real-world. Participants playing a computer game for an hour for a small amount of money may behave very differently to prehistoric hunter-gatherers making arrowheads to hunt for food to feed their families. This is why experimental simulations (and purely theoretical models) must always be conducted in conjunction with historical, archaeological and ethnographic studies, the high internal validity and low external validity of the former complementing the high external validity and low internal validity of the latter (Figure 7).
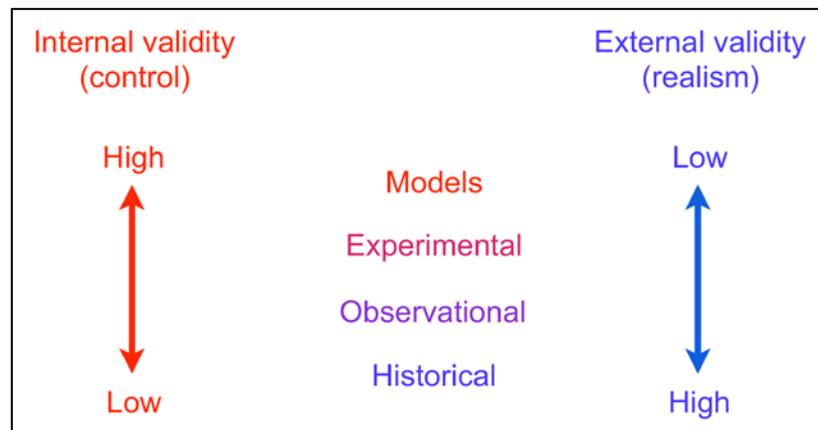

Figure 7
Multiple methods complement one another's strengths and weaknesses

Summary

Analysing cultural change as a Darwinian evolutionary process brings with it two huge advantages over traditional, non-evolutionary SSH approaches (Mesoudi, forthcoming). First, we can borrow a set of well-established, powerful quantitative methods and theories developed in biology, adapt them where necessary, and use them to explain cultural phenomena in a rigorous, quantitative, scientific manner. Primary amongst these are population-genetic-style modelling techniques that link individual-level, microevolutionary processes to population-level, macroevolutionary phenomena, thus solving the perennial "micro-macro" problem that has hindered progress in the SSH. Second, evolutionary theory provides a synthetic framework within which different SSH

disciplines can be integrated. This is not interdisciplinarity for interdisciplinarity's sake: different methods (e.g. experimental, theoretical, observational, historical) directly complement one another's strengths and weaknesses to the mutual benefit of all. Yet this is just the beginning of an evolutionary "cultural science". While these methods are useful for simple, well-defined problems such as explaining artefact diversity in a specific region and time period, it will be a much greater challenge to explain phenomena central to the SSH such as large-scale, hierarchically-organised cooperative social institutions or co-evolving technological and economic systems, phenomena which may have no parallel in genetic evolution and which may require entirely novel evolutionary approaches.

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