I agree with Mesoudi et al. that much of value can be borrowed from what we know of Darwinian biological evolution and adapted (not just adopted) to cultural phenomena (e.g., Lyman & O'Brien 1998; O'Brien & Lyman 2002a). But I also think that Mesoudi et al. and those who hope to develop Darwinian social sciences have some significant work to do. Mesoudi et al. touch on one topic that is critical to the enterprise but that has, as yet, received limited attention from socio-behavioral scientists: What is the unit of cultural transmission? Mesoudi et al. mention memes, the still ambiguously and incompletely conceived unit of choice for many; I found Aunger's (2002) discussion of memes helpful to my own conceptualizing, but it focused largely on modern ideas about such units and ignored historically antecedent ones. The tendency today is to devote considerable attention to modern studies of the pathways of cultural transmission (e.g., Richerson & Boyd 2005 and references therein) and to ignore the deep history of studies of cultural transmission mechanisms, modes, and processes (see Lyman [in press] for a review of pertinent early ideas). Hence, many researchers seem unaware of the historical conceptualization of a unit of cultural transmission in anthropology (Lyman & O'Brien 2003). That unit is the "cultural trait," a term Mesoudi et al. use like many modern researchers in the social and behavioral sciences use it – without an explicit definition; though how Mesoudi et al. and others use it does imply that a cultural trait, whatever else it might be, is a unit of cultural transmission.

Those interested in developing Darwinian social science should study the history of their discipline, whether anthropology, sociology, or psychology, to learn what our intellectual ancestors thought about cultural transmission. From what I have read of their ancient writings (Lyman, in press; Lyman & O'Brien 2003), they had some good ideas that might help us build models of cultural transmission that include explicitly conceptualized units and processes of transmission. To illustrate, I summarize how a cultural trait was, and is still, conceived by many anthropologists, and I describe one key process of cultural transmission and its effects discussed more than 100 years ago.

To early twentieth-century anthropologists, cultural traits were units of cultural transmission that were diffused, learned, borrowed, and perpetuated (usually but not always) by face-to-face contact. A trait could vary in scale from the color of a decorative motif on a ceramic vessel to an entire behavioral complex such as the nineteenth-century Ghost Dance – a revitalization movement with elements of Christianity and indigenous religion and ritual that appeared and spread across portions of the western United States several times (DuBois 1939; Mooney 1896; Spier 1935). A modern conception of a cultural trait would be that of a recipe – how, when, where, and why to produce a behavior or an artifact (a behavioral by-product). A cultural trait (recipe) includes a set of ingredients, rules for acquiring ingredients, rules for preparing and measuring ingredients, rules for mixing and cooking (metaphorically) ingredients, and what to do with the finished product (Lyman & O'Brien 2003). Rules, ingredients, or both can be transmitted individually or as a more or less complete set, and can be mixed or altered to produce (metaphorically) a chocolate cake or a yellow cake, or a cookie or a pot roast.

Conceiving a cultural trait to be such a plastic entity is advantageous. A trait can vary in terms of its scale (inclusiveness), whether it is empirical or not, its mechanical constraints, and its tolerance limits (how closely must a recipe be followed to result in a suitable product?). With respect to transmission processes, can a cultural trait be integrated in a recipient culture or not? Integration was a process that seminal American anthropologist Franz Boas identified that allowed the tracking of cultural traits across time and space. Integration was the process by which a cultural trait was "adapted and changed in form according to the genius of the people who borrowed it" (Boas 1896, p. 5). The "adapting and changing" of a cultural trait comprises integration. Boas believed that in order for a newly acquired cultural trait to be retained and replicated, it had to be modified to fit its new cultural context (Hatch 1973). Because many traits were acquired piecemeal from many and disparate sources, and such acquisition never stopped within a culture, integration was ongoing and resulted in a culture comprising a set of functionally and structurally interrelated traits that were modified to greater or lesser degrees from their original state. In Boas's view, integration was one of, if not *the*, "creative force" of culture. Thus, it was not only a process of transmission (on the receiving end), but it also had an effect on the general processes of cultural evolution and cultural transmission because it created new variants of cultural traits (which were subject to sorting processes such as natural selection, though Boas did not refer to sorting).

Mesoudi et al.'s effort is thoughtful, and it is also up-to-date conceptually. But to borrow a worn cliché, they and we ignore history at the peril of repeating old mistakes, and, I would add, at the peril of forgetting what our intellectual predecessors learned.

A long way to understanding cultural evolution

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Abstract: Understanding cultural evolution is one of the most challenging and indispensable scientific tasks for the survival of humankind on our planet. This task demands, besides an adoption of theories and models from biological evolution, theories for culture-specific processes as well. Language evolution and language acquisition offer interesting objects of study in this respect.

Mesoudi et al.'s review of concepts and models from biological evolution theory and their demonstration of numerous, amazing analogies and parallels between bio-evolution and cultural evolution is commendable. The long tradition, the generally high scientific level, and the wealth of reliable results of bio-evolution theory provide an excellent starting point for developing a scientific theory of cultural evolution. We strongly support the authors' view that it is a promising strategy to exploit these parallels and to apply the rich inventory of methods from biological evolution theory as far as possible. This should be done not only in terms of heuristics, but also in terms of mathematical modeling to the extent and depth as the necessary verifications allow.

Despite the fascinating parallels between biological and cultural evolution, however, which are mostly due to the structural similarity of certain interaction processes, there also exist certain essential differences between the two kinds of evolution processes. Complementing the examples given by Mesoudi et al., we would like to draw attention to the following: Traits in cultural evolution are more difficult to define and to identify; and they often have lower persistence and resilience. There is no stringent translation of the terms *individual, species, population, gene*, and so on, **in** corresponding analogs. Additional complications come up when we investigate cultural evolution as historical process: Often we find ourselves as acting a part on the stage. Decisions and valuations at all levels of society may act as selective forces. Expectations, beliefs, and predictions may become self-enforcing, even self-fulfilling, or self-defeating. Ecosystems are generally robust, resilient, and structurally stable against local impacts and disasters; cultural communities are, in contrast to this, much more vulnerable and manipulable. Local disturbances may have long-range and long-term consequences, and could become amplified violently and epidemically. In investigating

https://doi.org/10.1017/S0140525X06359080 Published online by Cambridge University Press

the cultural evolution of real historical communities, one has to consider economic subsystems, metabolism with the environment, corresponding energy flows, and information streams, as well as driving forces and constraints all the way down to the basic physical and thermodynamic laws. Otherwise we cannot understand the emergence, progression, and eventual collapse of these communities (see Diamond 1999; 2005). However, it should be possible to incorporate these culture-specific aspects in more advanced models of cultural evolution. The best-quality criteria are exhaustive tests of their predictive power.

Following Richerson and Boyd (2005), Mesoudi et al. adopt a rather wide definition of "culture" as "information capable of affecting individuals' behaviour that they acquire from other members of their species" (target article, sect, 1, para. 10). According to this wide definition, language should get a high valuation because language qualifies as one of the most powerful tools affecting individuals and groups. We missed all the more a discussion of language beyond cladistics and learning. Language is such a primordial and fundamental constituent of culture that it deserves closer and specific attention. Moreover, language is also a unique motor of human cultural evolution, without any parallels in the history of nonhuman life. From the phylogenetic perspective, there is clearly a close coevolution of culture and language. This causes a deep impact of language on cultural evolution. Application of spoken or written language has dramatically shaped nearly all fields of culture, especially communication, on all scales and continuously creates new selective forces with sometimes high fluctuation amplitudes. Language is also responsible for fast-changing spiritual vogues, for intellectual fashions and ideologies, all unique to the human being – again, with no counterpart in the natural history of other biota.

Language evolution and language acquisition could therefore provide interesting objects of study for cultural evolution processes: The hereditary predisposition of an infant for the acquisition of any language is a clear vertical transmission process; the fast and seemingly effortless acquisition process itself is a maturation-controlled learning process with prevalent horizontal transmission. Both processes are coupled by the unique feature of testing and reshaping of coevolving language by a co-developing brain (Wermke & Mende 2006). Language acquisition is universal and at the same time highly flexible. The mastering of native languages is one of the necessary preconditions of cultural traditions.

To illustrate the growing gap between evolution of biota and cultural evolution, one should also consider the breathtaking acceleration made by the energy technology of the nineteenth century and even more so by contemporary information technology. The hyperlinked, interlocked global village has no counterpart in biological evolution. It is threatened by an intrinsic explosion of complexity, by the outbreak of good and evil fantasies, and urgently needs new strategies of stabilisation. Supreme effort is required to model and, most important, to understand these cultural evolution processes and to make reliable predictions and decisions. Modeling approaches have to take into account that far-reaching decisions are the result of the interaction of a large number of human brains and that even individual responses are generally the result of a huge potential for imagination and fantasy inside and outside of human brains. The progeny of Darwin, vertically and horizontally fairly well instructed, has to solve this puzzle as soon as possible. A deeper understanding of the underlying mechanisms of cultural evolution might be crucial for finding the trail toward a balanced and sustainable future of humankind.

Archaeology and cultural macroevolution

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Abstract: Given the numerous parallels between the archaeological and paleontological records, it is not surprising to find a considerable fit between macroevolutionary approaches and methods used in biology – for example, cladistics and clade-diversity measures – and some of those that have long been used in archaeology – for example, seriation. Key, however, is recognizing that this methodological congruence is illusory in terms of how evolution has traditionally been viewed in biology and archaeology.

Mesoudi et al.'s general premise is that human culture exhibits central Darwinian properties. They then ask a question that grows out of this premise: What sort of structural relationship might exist between a science of cultural evolution and the science of biological evolution? They divide biological evolution into macro- and microevolution and then align various methods and approaches used to examine each with corresponding methods and approaches used to examine cultural evolution. They find a considerable fit between macroevolutionary approaches in biology and some of the approaches used in anthropology and archaeology, and less fit between microevolutionary approaches. This is not surprising, given the numerous parallels between, say, the archaeological and paleontological records, which lend themselves to macroevolutionary methods such as cladistics, seriation, and clade-diversity measures. Likewise, the history of anthropology makes it clear that macroevolutionary approaches such as comparative anthropology are the backbone of the discipline.

Because of their focus, Mesoudi et al. necessarily bypass discussion of the "evolution" of these interests, approaches, and methods in anthropology and archaeology – a topic that Lyman and I have detailed elsewhere (e.g., Lyman & O'Brien 1997; 1998; Lyman et al. 1997; O'Brien & Lyman 2000). Here I point out that the considerable fit that Mesoudi et al. find between macroevolutionary approaches, methods, and issues in anthropology/archaeology and those in biology is a recent phenomenon rather than a long-standing tradition in the social sciences. The irony is that despite the parallels between subject matter, and despite the "naturalness" of traditional anthropological and archaeological methods for addressing cultural-evolutionary issues, social scientists have often been downright hostile toward even considering cultural evolution in Darwinian terms. Rather, they retreat to the cozy confines of nineteenth-century unilinear and progressive cultural evolutionism of Tylor (1871) and Morgan (1877).

Anthropologists and archaeologists have been encouraged in this retreat by several prominent biologists and paleobiologists such as Gould (e.g., 1987; 1996; 1997) and Mayr (1982; Angier 1997), who have done what countless anthropologists have done for more than a century – moved culture from the Darwinian realm into the Lamarckian realm. Note how Gould (1996, p. 222) viewed the situation:

> [the] uniquely and distinctively Lamarckian style of human cultural inheritance gives our technological history a directional and cumulative character that no natural Darwinian evolution can possess. . . . [C]ultural change is potentially progressive or self-complexifying because Lamarckian inheritance accumulates favorable innovations by direct transmission, and amalgamation of traditions allows any culture to choose and join the most useful inventions of several separate societies.

This misguided gambit locates cause in the wrong place (O'Brien 1996). Although the mode and tempo of transmission are different when culture is involved, do these differences lead to the inescapable conclusion that humans have stopped evolving – that they somehow are beyond the reach of selection? The answer is an emphatic "no." Humans today are no more immune to evolutionary processes than they were ten thousand or fifty thousand years ago.

All that is important in Darwinian terms – and it is difficult to overemphasize this point – is that variation, however it is generated, exists, and that transmission, however it is realized, takes

https://doi.org/10.1017/S0140525X06359080 Published online by Cambridge University Press