論文の内容の要旨

A Memetic Theory of Cultural Evolution and its Applications to Linguistics

(文化進化のミーム的モデルとその言語学への応用)

氏名 ルーク マクロホーン

Our species, homo sapiens, is unique in many ways. We are a highly intelligent, extremely social species, possessing a singularly complex linguistic communication system and the ability to craft specialized tools allowing us to survive in almost any environment. We create music and art, build cities, seek to explain the world around us, and even show a willingness to sacrifice ourselves in the name of abstract ideas. Given our range of peculiar traits, it is important that any account of our evolutionary origins explain not only what we have in common with other species, but also what gave rise to our uniqueness.

One recent strand of evolutionary thinking provides such an explanation, it argues that in our lineage the emergence of cultural learning fundamentally altered the way evolution operates in our lineage. Rather than being solely the product of biological evolution, our recent evolution is the result of interactions between genes and culture, and can only be understood in terms of this combined process of gene-culture coevolution (Blackmore, 1999; Boyd and Richerson, 1985; Richerson and Boyd, 2006; Dawkins, 1976; Deacon, 1997; Durham, 1991).

While their are strong arguments supporting this theory, currently our poor understanding of the process of cultural change restricts its applications. Although a large number of theories of cultural evolution have been proposed, the majority depend on ad hoc, post factum reasoning that does not offer the sort of predictive capacity needed to derive coevolutionary explanations. What is needed is a theory cultural evolution which is, both, applicable in the general case, and which can make predict how culture will change in response to particular biological environments.

The potential foundation for such a theory can be found in Dawkins' (1976) concept of a meme; a replicating unit of cultural information. Several authors have attempted to build darwinian theories of cultural evolution based on this
idea (e.g. Blackmore 1999; Hull 1988; Brodie 1996; Gabora 1997; Lynch 1998 etc.), but they have generally failed to reach any sort of consensus on what such a theory should look like. But perhaps more significantly, their attempts have been met with widespread criticism for a variety of reasons and from a range of sources (e.g. Sperber 1996; Rose 1998; Blooch 2000).

In this thesis I argue that the main source of disagreement between existing theories, and also the cause of much of the criticism, stems from the overzealous application of biological ideas to memetic theories of cultural evolution. This occurs both on the part of proponents of these theories, and on the part of those seeking to criticize them. I identify several criticisms from the literature which I argue are examples of this over-application. I then show that in many cases, even though these criticism are biologically inspired, they seek to place constraints that even biological evolutionary theory cannot live up to. As evidence of this, I present examples of evolutionary processes in biology that would run afoul of the objections raised against memetics.

I then make the more significant contribution of showing that if we discard the single-stage biological model of replication in our definition of memes that much of the disagreement between authors in the memetic literature can be resolved. I do this by introducing a two stage life-cycle model of memetic replication, which links the brain-internal products of culture, i-memes, with the brain-external products, e-meme, as distinct stages in the meme replication process. This definition has the advantage of making the cultural germ line explicit, which prevents misleading claims of Lamarckian inheritance, and it also makes it possible to capture Blackmore's (1999) distinction between copy-the-product and copy-the-instructions memes which has been problematic in earlier models.

By separating the memetic lifecycle into two stages, the replication process is also separated into two distinct steps; production and learning. This is significant as it is often the case that memetic traits which make replication at one step easier, impede replication at the other. For example, variations that make the production of an e-meme more desirable, often make the associated i-meme more difficult to learn. When working with a traditional single stage model of meme replication, it is hard to separate these opposing effects, making the discussion of the adaptive benefit of particular cultural properties difficult. The two-stage model suffers from no such limitation.
Further, by allowing the quantification of replicative success at the two steps in isolation, the two-stage life-cycle model makes it possible to categorized meme replication strategies according to their average replication frequency at each step. This adds an extra dimension to the discussion of

the life history strategies adopted by memes, and allows predications to be made as to the most successful type of memes in particular kinds of socio-cultural environments.

A final advantage of the two-stage model is that it provides a new perspective on the debate surrounding the relevance of a replicator/vehicle distinction to memetics. Originally proposed in biology to clarify arguments about the level at which selection operates, the distinction has been widely borrowed into memetic theories of cultural evolution, where it is used in several contradictory ways. From the perspective of the two stage life-cycle model I argue that regardless of whether such a distinction can be made with regards to culture, the current uses of the term 'vehicle' in the memetics literature completely miss the point that lead to the term's introduction in biology.

In relation to questions concerning the size of memes, and their replication fidelity, I address several common misconceptions, and argue that there is no theoretical requirement for memes to be defined as clearly delimited discrete entities as some seem to believe (Bloch, 2000). This is important as I also argue that no such discretization is actually possible, and that a key property of cultural information is the continuous degrees of linkage possible between concepts. Unlike in biology, linkage is not determined by the physical arrangement of replicators, but as a result of their specific properties. This is shown to have important affects on the ways in which memes can coevolve with each other, which in turn has important implication for the selection pressures they are subject to.

The arguments presented in so far are intended to put memetic theories of cultural evolution on a stronger theoretical foundation, not to provide a full theory of memetic evolution. It is thought that this stronger foundation should give us more confidence in the claims made by memetic theories of cultural evolution. First that cultures are not unitary entities but temporary aggregates, second that the components of these aggregates evolve purely to enhance their own replication, regardless of the effects this may have on each other, or us, their hosts. In the remainder of the I applies these and other memetic ideas to the study of the evolution of human language. In doing this, it is my aim to show that memetic theories are not just possible, but also have practical applications.

Before proceeding to practical applications, I first explain the core methodological difficulties involved in the study of the evolution of language; the limited availability of direct historical evidence and the necessity to understand the evolutionary interactions of biology and culture. It is argued that these difficulties are responsible for the heavy use of computational simulation by researchers working in this area. The perceived benefits and some of the potential pitfalls of this approach are discussed. A software framework designed to make modeling results more accessible to non-programmers is introduced, which will be used for modeling in all subsequent sections.

To demonstrate the way modeling is used in practice I give an in-depth analysis of one recent

coevolutionary model from the language evolution literature, which was designed to investigate the coevolutionary emergence of linguistic learning biases (Yamauchi and Hashimoto, 2010). It is shown that several key behaviors reportedly displayed by this model are the result of arbitrary decisions made during its design, and are not the result of emergent properties in the underlying coevolutionary system being studied. This is shown to invalidate the central arguments made in the original paper, and serves as a stark illustration of the care that needs to be taken when utilizing computational models.

I then apply the memetic perspective to the evolutionary development of the modern human lexicon. It is argued that the lexicon is larger than is strictly biologically necessary, and that its size imposes significant biological costs. This has previously been explained as the result of sexual selection (Miller, 2000), but I suggest an alternative explanation in terms of an evolutionary arms race between our ancestors and their culturally evolving lexicons. To investigate this hypothesis I develop and analyze a computational simulation of lexicon evolution, which provides evidence as to the plausibility of the coevolutionary scenario I propose given certain easily justifiable assumptions.

Next I apply the memetic to the explanation of observed patterns of lexical diffusion between languages in show certain word classes are more frequently borrowed (Haugen, 1950). I argue that the Complexity Hypothesis (Jain et al., 1999) from molecular genetics, which explains an analogous pattern of horizontal transfer in biology, can be generalized to apply to borrowing between any coadapted darwinian system, including languages. I argue that this generalized complexity hypothesis can explain the observed patterns of borrowing, and may also play a role in determining rates of language internal change. I construct a computational model of populations of lexical learners in which coadaptation affects learnability and demonstrate that in this model the complexity hypothesis produces the predicted effects.

Having spent the last few years studying language from a darwinian perspective I have come to believe that what Dobzhansky (1973) said about biology, applies equally to linguistics:

"Nothing in linguistics makes sense except in the light of evolution."

It has been my goal in writing this thesis to add to the case in support of this statement. If I have been successful, I will have convinced readers of both the possibility, and the importance, of developing a darwinian science of language.