Ted Briscoe (ed.), *Linguistic Evolution through Language Acquisition.* Cambridge, UK: Cambridge University Press, 2002. Pp. vii + 349.

Reviewed by SHIMON EDELMAN and BO PEDERSEN, Cornell University

In 1990, when Steven Pinker and Paul Bloom proposed that 'there is every reason to believe that a specialization for grammar evolved by a conventional neo-Darwinian process' (Pinker and Bloom, 1990), the consensus in linguistics had been, for a long time, quite the opposite: 'It is perfectly safe to attribute this development to "natural selection", so long as we realize that there is no substance to this assertion' (Noam Chomsky, *Language and Mind*, 1972, p.97). A decade later, inquiry into the evolutionary emergence of language is no longer shunned by most scholars (Christiansen and Kirby, 2003), due both to the seminal work of Pinker, Bloom and others in the psychology of language and in linguistics, and, crucially, to the steady stream of insights offered by formal analysis and computational simulations of language evolution. The present volume, edited by Ted Briscoe, is an excellent collection of work in the latter tradition.

Despite what the jacket says, this book is not about how children acquire language. Rather, the authors examine (sometimes analytically, but mostly through computer simulation) the developments that occur in populations of simple agents endowed with certain proto-linguistic capabilities. The dependence of the outcome of such studies on working assumptions (such as the agents' access to structure-meaning pairings), and the justification for calling the resulting communication system 'language' — the two central concerns of the present review — are discussed in depth in chapter 1 ('Introduction', by Ted Briscoe, the collection's editor), and in the concluding chapter 10 (by James Hurford; see below). The eight remaining chapters offer multi-faceted insights into how various aspects of language may have emerged: chapters 2 and 3 deal with words and word meanings, while chapters 5 through 9 focus on structural ('syntactic') issues. Chapter 4 ('Linguistic structure and the evolution of words', by Robert Worden) very appropriately bridges the two themes.

In chapter 2, 'Learned systems of arbitrary reference: the foundation of human linguistic uniqueness', Michael Oliphant's neural networks use standard learning algorithms such as the Hebb rule to acquire consistent form-meaning pairings. The difficult aspects of this problem, as Oliphant remarks on p.47, have less to do with learning than with *observing meaning*. Interestingly, the process of spoon-feeding meanings to agents is automated (if not obviated) in the following chapter, 'Bootstrapping grounded word semantics', in which Luc Steels and Frederic Kaplan describe agents that learn word meanings by playing a Wittgensteinian language game (p.71) in which they try to communicate to each other descriptions of shared visual scenes. This approach works fine for well-grounded content ('RED at [0.25, 0.75]'), but is bound to be more challenging for more abstract stuff such as 'Jack is happy', let alone 'meaning is elusive').

The work of Robert Worden, described in chapter 4, 'Linguistic structure and the evolution of words', should be of a special interest to linguists, in part because Worden's contribution is the most elaborate in specifying the actual details of language (at the other extreme lies the work of Niyogi, chapter 7, and Turkel, chapter 8). Worden adopts a unification-based framework, which parallels familiar formalisms such as Head-driven Phrase Structure Grammar. In his work, populations of words rather than of language users are the entities that evolve (this interesting and potentially very fruitful approach to language evolution is championed also by Kirby, and by Christiansen). Words are represented by feature structures, which are learned from sets of related exemplars by 'generalization' (a kind of structured intersection) and are used through unification. Among the many exciting issues raised and addressed in this chapter are (1) the role of unification and generalization in ambiguity resolution, (2) Bayesian inference, a statistical theory of unsupervised learning that is universally important in cognition (Barlow, 1990) and is related to the Minimum Description Length principle (Clark, 2001), and (3) evolutionary aspects of language universals of Greenberg and of Hawkins.

In chapter 5, 'The negotiation and acquisition of recursive grammars as a result of competition among exemplars', John Batali introduces a computational model in which agents optimize their grammars by observing the phrase/meaning pairs of other agents. His item-based approach to representation and learning has parallels to important psycholinguistic findings on language acquisition (Tomasello, 2000). It could, however, be better integrated with other work in the field (for example, instead of invoking structure unification, the concept that is at the core of Worden's work, Batali swamps the reader with his own terminology, newly introduced at every turn). Moreover, his approach to learning is supervised in that agents have access both to exemplar structures and to their meanings, greatly diminishing the potential relevance of his findings to real language acquisition and evolution.

The book's quest for the understanding of language evolution is revitalized by Simon Kirby in chapter 6, titled 'Learning, bottlenecks and the evolution of recursive syntax'. Kirby shows how E-language, acting as a bottleneck for the transmission of I-language, constrains the set of meanings to which learners are exposed, allowing only the most general grammar rules to survive (like Worden, Kirby treats language itself as a system of replicators). He shows that compositionality and recursion, two central traits commonly attributed to natural languages, can emerge through cultural transmission, and thus need not be innate. While this finding constitutes a great success for the computational approach to the understanding of language evolution, it is also conceptually problematic, if only because compositionality posits links between structure and meaning that are essentially stipulative (cf. Hurford, p.319). The well-known way to introduce and manage principled, data-driven links of that kind — Construction Grammars (Goldberg, 2003) — is not mentioned in the present volume.

The following two contributions, Partha Niyogi's 'Theories of cultural evolution and their application to language change' (chapter 7) and William J. Turkel's 'The learning guided evolution of natural language' (chapter 8), both focus on the mathematical analysis of the evolution of small sets of parameters that control grammars (rather than on grammars or on syntactic structures as such). Niyogi formalizes the dynamics of a simplified situation involving language change (namely, the case of two languages in contact), and proceeds to apply the resulting framework to the analysis of the historical transition from Old to Middle to Modern English. Turkel, who also relies on the Principles and Parameters theory, shows, using simulations with plastic vs. fixed parameters, that learning can accelerate the evolutionary process. The upshot of this finding is that language could have evolved even if even one accepts the claim that it cannot exist in intermediate forms. When evaluating these results, one should keep in mind that the simulations in question did not involve actual language (even of a highly simplified nature, such as the languages acquired by Worden or Kirby's models), an observation that is especially relevant in the light of the known difficulties with the so-called triggered learning of actual language – rather than of abstract parameter sets – from corpus data (cf. Briscoe, p.256).

In chapter 9, ‘Grammatical acquisition and linguistic selection’, Ted Briscoe employs an intriguing combination of techniques from linguistics (the Generalized Categorial Grammar formalism), computer science (a GCG parser) and computational learning theory (Bayesian inference) to make several points that should be of interest to all students of language. In particular, Briscoe demonstrates that an innate language acquisition device could have co-evolved with human (proto)language(s); he also offers interesting insights into the computational underpinnings of such central phenomena in linguistics as categories of language families based on word order, and creolization.

An excellent synthesis of the plethora of models and findings contained in the present collection is presented in the concluding chapter 10, ‘Expression/induction models of language evolution: dimensions and issues’, by James R. Hurford. The most important of Hurford’s many useful observations is that a convincing demonstration of language evolution would have to show that syntax can be a truly emergent phenomenon and not just a reflection of the system’s design. For that, Hurford concludes on p.302, evolutionary linguistics needs a theory-free definition of syntax — a notion that is likely to ruffle quite a few feathers among the scholars of language.

The most important contribution of this book is in the many detailed examples of the emergence of structured representations that it offers. The advances reported here, which occur on the many fronts surrounding the issue of language evolution, would be impossible, were it not for the rigorous methodology adopted by the contributors. Thus, Briscoe is entirely justified in claiming that the use of mathematical modeling and/or computational simulation is vital (‘Introduction’, p.15): without it, even the very plausible accounts of language evolution remain just so stories. Computational modeling in itself, however, is not a panacea against irrelevance, because the current theories of grammar on which any such model is based are all, at present, merely descriptive. That is, we have, as yet, no viable process model for language, and with a descriptive model there is a distinct possibility that the features we believe to be important are in fact immaterial. One may observe that the simulation approach is much safer (and more productive) in engineering, where the problems at hand tend to be well-formulated: consider, for example, the airflow around a wing, where all the relevant physical variables are known, even if the equations are analytically intractable and computationally complex. Getting closer to evolutionary simulation, one may observe that the better known successes of game theory, such as the evolution of cooperation in iterated Prisoner's Dilemma, involve situations where all and only relevant variables are known and are easily represented numerically. In contrast, in language there is no universally agreed-upon formalization (theory of grammar), nor even a list of core phenomena to be formalized ('theory-free syntax').

In the absence of consensus (let alone of deep physical reasons) regarding the relevance of a given formalization of the problem, it is imperative to address the widespread concern that simulations are 'doomed to succeed' ('Introduction', p.18) in that they always produce *some* result. To our mind, this means that when applying the simulation approach to the study of language evolution, one must make sure that the evolving structures are capable of reflecting at least some key properties of natural language, lest they become irrelevant (cf. Hurford, p.301: 'The models of the evolution of syntax that have been constructed so far fall short of the kind of syntactic complexity found in real languages'). In particular, in linking language evolution to language acquisition (as the book's title suggests), it would be useful to consider a psychologically relevant and computationally viable approach to the latter as a basis for the former. One possibility that seems to us particularly attractive is to use for that purpose some variety of Construction Grammar, because construction-like representations can be learned from examples in an unsupervised fashion (Solan et al., 2003), because they naturally integrate structure and meaning (Goldberg, 2003), and because they are supported by a growing body of data in developmental psycholinguistics (Cameron-Faulkner et al., 2003).

Authors' address: Department of Psychology, Cornell University, Uris Hall, Ithaca, NY 14853-7601, USA
E-mail: se37@cornell.edu

References

Barlow, H. B. (1990). Conditions for versatile learning, Helmholtz's unconscious inference, and the task of perception. *Vision Research*, 30:1561–1571.

Cameron-Faulkner, T., Lieven, E., and Tomasello, M. (2003). A construction-based analysis of child directed speech. *Cognitive Science*, 27:843–874.

Christiansen, M. H. and Kirby, S. (2003). Language evolution: the hardest problem in science? In Christiansen, M. H. and Kirby, S., editors, *Language Evolution*, pages 1–15. Oxford University Press.

Clark, A. (2001). *Unsupervised Language Acquisition: Theory and Practice*. PhD thesis, COGS, University of Sussex.

Goldberg, A. E. (2003). Constructions: a new theoretical approach to language. *Trends in Cognitive Sciences*, 7:219–224.

Pinker, S. and Bloom, P. (1990). Natural language and natural selection. *Behavioral and Brain Sciences*, 13:707–784.

Solan, Z., Ruppin, E., Horn, D., and Edelman, S. (2003). Unsupervised efficient learning and representation of language structure. In Alterman, R. and Kirsh, D., editors, *Proc. 25th Conference of the Cognitive Science Society*, Hillsdale, NJ. Erlbaum.

Tomasello, M. (2000). The item-based nature of children's early syntactic development. *Trends in Cognitive Science*, 4:156–163.