To be fluent or not to be (at all) – in the evolutionary naming-game model

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Recently, the emergence and evolution of language attracts a growing interest. In this interdisciplinary field problems like differentiation of languages, development of the speech apparatus or formation of linguistically connected social groups require joint efforts of many specialists such as linguists, neuroscientists, or anthropologists. However, there are also more general questions concerning this almost exclusively human trait. Why do we use words and then combine them into sentences? Why all languages have grammar? To what extent is our brain adapted for acquisition of language? Can learning direct the evolution? These questions justify an increasing involvement of researchers also from other disciplines such as artificial intelligence, computer sciences, evolutionary biology or even physics.

Computer modeling is a frequently used tool in the studies of language evolution. In this technique two main approaches can be distinguished. In the first one, known as an iterated learning model, one is mainly concerned with the transmission of language between successive generations of agents. The important issue that the iterated learning model has successfully addressed is the transition from holistic to compositional language. However, since the number of communicating agents is typically very small, the problem of the emergence of linguistic coherence must be neglected in this approach. To tackle this problem L. Steels introduced a naming game model. In this approach one examines a population of agents trying to establish a common vocabulary for a certain number of objects present in their environment. The change of generations is not required in the naming-game model since the emergence of a common vocabulary is a consequence of the communication processes between agents.

It seems that the iterated learning model and the naming-game model are at two extremes: the first one emphasizes the generational turnover while the latter concentrates on the single-generation (cultural) interactions. Since in the language evolution both aspects are present, it is desirable to examine models that combine evolutionary and cultural processes. In the model we have introduced agents try to establish a common vocabulary like in the naming-game model, but in addition they can breed, mutate, and die. Moreover, they are equipped with an evolutionary trait: learning ability. As a result evolutionary and cultural (learning from peers) processes mutually influence each other. When communication between agents is sufficiently frequent, cultural processes create a favourable niche in which a larger learning ability becomes advantageous. But gradually increasing learning abilities in turn speed up the cultural processes. As a result the model undergoes an abrupt bio-linguistic transition. The proposed model suggests that linguistic and biological processes at a certain point of human history after crossing a certain threshold started to have a strong influence on each other and that resulted in an explosive development of our species. That learning in our model modifies the fitness landscape of a given agent and facilitates the genetic accommodation of learning ability is actually a manifestation of the much debated Baldwin effect.

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