

# Cultural language evolution: acquisition or usage?

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A central question for evolutionary approaches to language on a historical time scale is what should be considered as *replication* in a linguistic context. There are broadly speaking two possible answers. The *Iterated Learning Approach* (Briscoe, Hurford, Kirby, Lightfoot, Nowak and many others) assumes that languages are transmitted primarily via first language acquisition. On the other hand, researchers from the historical or functionalist tradition like Croft or Haspelmath argue that language change takes place via the language usage of mature speakers. In the following I will argue that the two perspectives are compatible and should both be taken into consideration.

Under the acquisition based approach, the dynamics of language change crucially hinges on the probability that an infant that is exposed to language  $L_i$  will acquire language  $L_j$  (for arbitrary  $i$  and  $j$ ). Under the simplifying assumption that there are finitely many languages, these probabilities form a square matrix  $Q$ . The population dynamics of language change can be approximated by the differential equation (which can be obtained from the corresponding equation in Nowak (2002) if the impact of linguistic behavior on biological reproduction is neglected, which seems plausible on a historical time scale):

$$\dot{x}_i = \sum_j x_j Q_{ji} - x_i \quad (1)$$

Here  $x_i$  gives the proportion of speakers of language  $L_i$  in the population.

Under the usage based approach, the *imitation dynamics*—which has been used in Evolutionary Game Theory to model cultural evolution—is a good candidate for a mathematical modelling of language dynamics. Here each pair of languages has a certain utility (which may be determined by functional and social factors like intelligibility, degree of ambiguity, or social prestige). With a certain (low) probability, an individual may give up its language and instead adopt another one. The higher the average utility of  $L_i$ , the more attractive it is as target of imitation. The simplest form of this is the *replicator dynamics* ( $U$  is the utility matrix):

$$\dot{x}_i = x_i \sum_j x_j (U_{ij} - \sum_k x_k U_{kj}) \quad (2)$$

If language change may be due both to imitation and to acquisition, we obtain the combined dynamics ( $b$  is a positive parameter that is correlated to the birth rate):

$$\dot{x}_i = x_i \sum_j x_j (U_{ij} - \sum_k x_k U_{kj}) + b \left( \sum_j x_j Q_{ji} - x_i \right) \quad (3)$$

A possible application of this combined model is a refinement of the evolutionary analysis of case marking systems I give in Jäger (2003, Amsterdam Colloquium) that is framed within the usage based model (2). Using corpus based estimates of utterance probabilities and a functionally motivated utility function, I came to the conclusion that only four case marking patterns are evolutionary stable: 1. split ergative, 2. differential subject marking, 3. differential object marking, and 4. zero marking. This is too narrow because pure accusative systems like Hungarian or standard Japanese are wrongly predicted to be unstable. The refined dynamics (3) remedies this. It is plausible to assume that it is more likely for an infant to overgeneralize a differentially object marking language to a pure accusative language than the other way round. So while usage favors split systems, acquisition leads to a bias towards pure systems, and both systems turn out to be evolutionary stable.