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MULTILAYERED FORMALISMS FOR LANGUAGE CONTACT

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1. Introduction

Since the constructive approach is advantageous for analyzing language evolution, a variety of methodologies have been proposed. However, each of them belongs to a different level of abstraction. Among simulation studies for population dynamics alone, an agent-based model (AM; hereafter) of language acquisition has been one representative as proposed by Briscoe (2002), while the other is a mathematical theory of the evolutionary dynamics of language called the *language dynamics equation* (LDE; hereafter) by Nowak, Komarova, and Niyogi (2001). AM is considered to be a concrete, or less abstract model though LDE is highly abstract. Especially, LDE is so abstract that the change of language is represented as the transition of population among a finite number of languages.

We focus on a series of language contact models in which levels of abstraction are different from each other (Nakamura, Hashimoto, & Tojo, 2003, 2008, 2009). Our purpose in this paper is to show behavioral differences by a parameter, comparing between the models on multiple levels of abstraction.

2. Constructive Approaches to the Emergence of Creoles

Thus far, Nakamura et al. (2003) proposed a mathematical framework for the emergence of creoles based on the LDE, showing that a certain ratio of contact among languages is necessary for creolization. Toward more concrete analyses, Nakamura et al. (2009) introduced Barabási-Albert networks (Barabási & Albert, 1999) (hereafter; BA-networks) as a social network to the framework, where each learning agent located on a vertex initially has one of three languages including a creole, and then chooses one for the next generation according to the probabilistic distribution based on similarity between languages. Experiments showed that local creole communities are organized in the large network, and one of three languages eventually dominates the whole network depending on parameters. Comparing with experiments with two-dimensional square lattice networks (Nakamura et al., 2008), each of whose vertex has immediate eight neighbors, a single language dominates in quite faster generations. Further analysis suggests that agents densely linked to neighbors have an effect on spreading a language, and unlike the lattice networks, such heterogeneous agents may disturb the equilibrium in language communities but in effect they lead to faster convergence. In other words, while the lattice network is analogous to the LDE in terms of conditions for creolization, in the BA network creolization is unlikely to occur, regardless of the contact ratio.

3. An Agent-based Model for the Emergence of Creoles

Since we aim at observing grammatical structures on the process of creolization, we have developed an agent based model with Kirby (2002)'s Iterative Learning Model on the social network, in which language similarity is measured using Levenstein distance between E-languages generated from I-languages. Figure 1 shows examples of the agent based model, where agents are connected to neighbors in the networks.

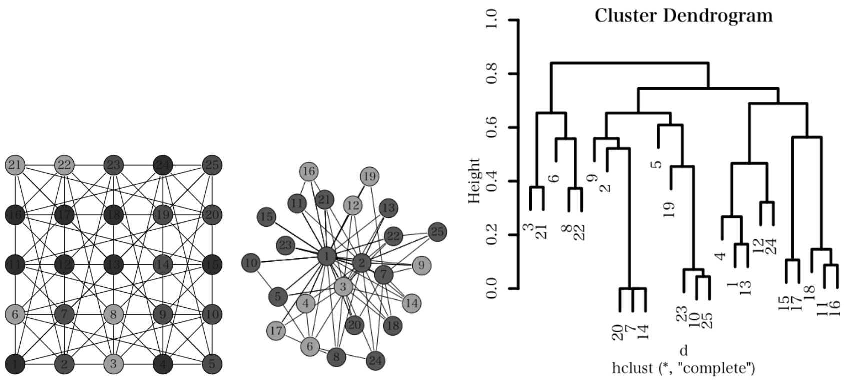

Figure 1. (Left) Language distribution in a two-dimensional square lattice network (Middle) in a BA-Network (Right) Cluster dendrogram, $N = 25$.

Since agents independently invent languages, their acquired languages are different from each other. In order to classify agents into groups of the similar language speakers, we introduce a clustering method, recognizing a cluster as a language group. The relationship among languages is represented by a dendrogram shown in the right hand side of Figure 1, where the vertical axis denotes height of the tree, the definition of which differs dependent on the clustering method. The number of languages, therefore, depends on the cutting point of the tree. In other words, it is possible to represent the dominance by a single language in any trial at the height of a merger of the last two clusters. For example, in the right hand side of Figure 1, the community is regarded as a single language community at the height of 0.84.

4. Conclusion and Future Work

Although we have expected that we acquire initial parameter settings by LDE in common, regardless of variety of model, this exact settings may differentiate the agent communication. We will continue to investigate the causality between parameters and agent models furthermore.

Currently we may be faced with a problem that has been reported by Smith and Hurford (2003); that is, in the case learning agents potentially have more than one cultural parent, the length of the right hand side of rules tends to increase rapidly over generations due to the addition of strings of meaningless terminal characters. Once this problem is solved, we will examine our agent based model with a huge number of agents.

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