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Self-Organization of Creole Community in a Scale-Free Network

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Abstract

Creolization is a self-organization process of new language community. Thus far, a simulation study of the emergence of creoles has been reported in a mathematical framework. In this paper we introduce a scale-free network to the framework. We show that local creole communities are organized, regardless of the degree of exposure to non-parental languages, in contrast to the non-spatial model, and that hub agents affect forming communities.

1 Introduction

A complex network is a set of vertices and edges with non-trivial topological features, which are considered to reflect social networks [2]. In this paper, we simulate a language phenomenon called creole in a scale-free network, recognizing vertices as individuals and the edges as the social interaction between them.

The emergence of pidgins and creoles is one of the most interesting phenomena in language change. Pidgins are simplified tentative languages spoken in multilingual communities. They come into being where people need to communicate but do not have a language in common. Creoles are full-fledged new languages which children of the pidgin speakers acquire as their native languages. Grammar of a creole is different from any contact languages, although its vocabulary is often borrowed from them [1]. Our goal is to discover specific conditions under which creoles emerge and spontaneously spread in the community.

Thus far, Nakamura et al. [3] proposed a mathematical framework for the emergence of creoles based on the language dynamics equation by Nowak et al. [5], showing that creoles become dominant under specific conditions of similarity among languages and linguistic environment of language learners. In addition, Nakamura et al. [4] introduced a spatial structure to the framework. However, its regular network is too simple to reflect a geographic or social situation where creolization occurs in the real world. Our purpose in the present study is to introduce a scale-free network, which shows a power law degree distribution like many real networks, and to investigate how it affects the self-organization process of creole community. We use the barabási-Albert (BA) model [2], which generates scale-free networks. Especially, in this paper we compare behaviors of the models with two networks.

2 Learning Algorithm and Transition Probability

The most remarkable point in the model of Nakamura et al. [3] is to introduce an *exposure ratio* α, which determines how often language learners are exposed to a variety of language speakers other than their parents. They modified the learning algorithm of Nowak et al., taking the exposure ratio into account in order to model the emergence of creole community. Nakamura et al. [3] have shown that a certain range of α is necessary for a creole to emerge.

The learning algorithm determines a transition probability $Q = \{q_{ij}\}$ that a language learner whose parent speaks G_i acquires G_j, given the distribution of population $X = \{x_i\}$, similarity among languages $S = \{s_{ij}\}$, the number of input sentences w, and the exposure ratio α.

In the BA model, we use the language distribution in neighbors surrounding each agent to calculate the transition probability Q. Each agent acquires a language according to the local transition probability.

3 Experiments and Results

In the BA model, we put 2,500 vertices (agents), each of which has at least 4 neighbors $(m = 4)$. Each agent chooses one of three languages every generation, two of which, G_1 and G_2, are pre-existing and randomly distributed with the same total number at the initial state. The remaining language, G_3, is a creole, having a certain similarity to two

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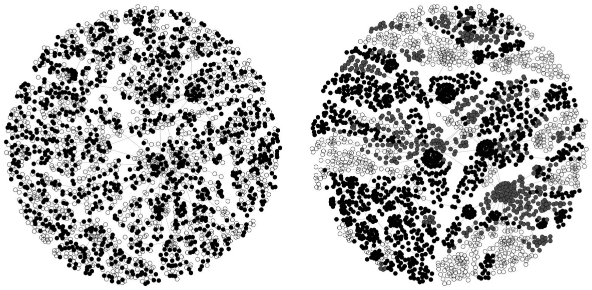

Figure 1. Example of the scale-free network (white:G_1, black:G_2, gray:G_3; $\alpha = 0.7$; $m = 1$)

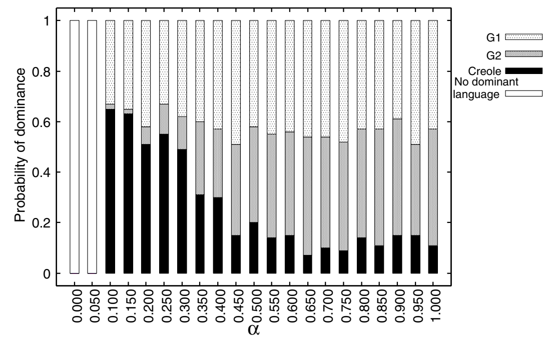

Figure 2. Probability of dominant language in the BA model

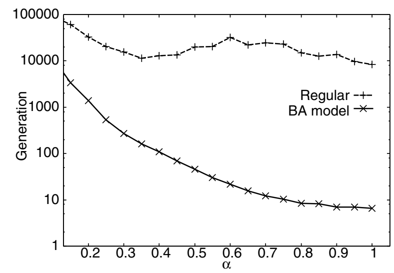

Figure 3. Comparison of convergent generation at each α

languages, which implies the probability that a sentence uttered by a G_i speaker is accepted by G_j. We take the following values: $s_{12} = s_{21} = 0$, $s_{13} = s_{31} = 0.3$, $s_{23} = s_{32} = 0.4$, $s_{ii} = 1$, and $w = 10$ for the number of input sentences. For the regular network, the configuration is the same as [4]. The total numbers of agents and edges are almost the same as the BA model.

We show an example of the scale-free network in Figure 1; (Left) Only G_1 and G_2 are randomly distributed at the initial stage. (Right) After generations, some local communities are formed and creole communities are likely to form at the intersection between G_1 and G_2 communities. Note that in order to make edges visible in Figure 1, we set the number of edges to $m = 1$, while $m = 4$ in the subsequent experiments.

We examine the probability of dominance for each language (Figure 2). This graph is the result of 100 runs at each α value. The corresponding results in the regular network and the mathematical model is shown in [4]. In the BA model, hub agents have a big influence on neighbors in terms of choosing a language, because the hub agents' language is hardly changed, supported by the majority of neighbors with the same language. Therefore, the language which most of hub agents have at the initial state is likely to become dominant. In other words, creolization is unlikely to occur, regardless of the value of the exposure ratio α.

We show in Figure 3 the difference of the average convergent generation when one of languages dominates the whole community. Because the hub agents effectively spread a common language in the BA model, the language dominance prevails on around the hub agents much faster than the regular network. It is commonly seen in both the regular and scale-free networks that at small values of α the convergent generations are slower. Because the exposure ratio α determines a probability that a language learner communicates with its neighbors, the learner is hardly affected by its neighbors. As a result, the small values of α make the emergence of a dominant language slow.

4 Conclusion

We showed, in the scale-free network, that the simulations converged much faster than the regular network. Hub agents strongly affect neighbors, and the same language communities are formed centering on the hub agents. When they acquire a creole, creolization is likely to occur. We conclude that the existence of hub agents matches the real situation of the emergence of creoles.

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