

## CO-EVOLUTION OF LANGUAGE AND SOCIAL NETWORK STRUCTURE THROUGH CULTURAL TRANSMISSION

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Language is transmitted over a population of language-users, and the structure of the population shows a marked effect on this transmission (Chambers, 2003). Population models of language evolution have shown that an emergent language is influenced by the structure and dynamics of the population in which evolves. It is also possible that the mechanism for language learning in turn affects the structure of the population in which the language learners are embedded.

Human populations are organised in social networks, which are structurally distinct from other networks (Newman & Park, 2003). Social network analysis aims to explain how the unique properties of social networks might arise. This study models network growth using a plausible mechanism, namely homophily, the tendency of individuals to establish and maintain social bonds with those to whom they are similar (McPherson et al., 2001). Further, this study models the co-evolution of social network structure and language by means of learning and interaction among agents in a dynamic population.

Boguñá et al. (2004) have shown that the presence of communities in a social space is sufficient to trigger social structure when the agents show a preference for similarity. However, they treat communities as predefined static entities. Centola et al. (2007) demonstrate the influence of homophily in the co-evolution of both network structure and cultural diversity.

We define a model of cultural transmission over a dynamic network using homophily and cultural learning. The model consists of a population of agents. Each agent is randomly assigned a position in the social space, represented by a vector of continuous real numbers. This is analogous to a number of linguistic traits that an individual possesses. The social distance between two agents is defined as the sum of the difference between each trait. The population is represented by an unweighted, undirected network of vertices. It is initially unconnected and evolves

by three methods – attachment to similar vertices, detachment from dissimilar vertices, and learning from adjacent vertices. These correspond to mechanisms of homophily and cultural learning events such as language learning.

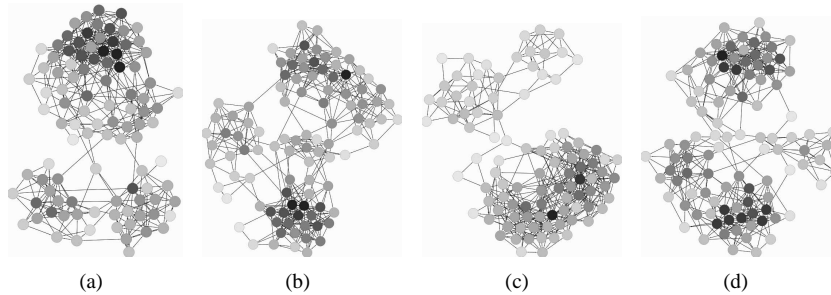


Figure 1. Typical networks with 100 agents and a single trait. The single trait of each vertex is represented by the vertex's shade.

Evolved networks (such as in Fig. 1) possess the characteristic measures of social networks: assortativity, transitivity and community structure (Newman & Park, 2003). The social distance shows a positive correlation with network distance, displaying emergent social clusters of similar languages. The rate of learning affects the size, density and linguistic diversity of the communities that form. This model demonstrates that the existence of one or more culturally transmitted traits and a preference for establishing and maintaining connections with similar individuals can lead naturally to social structure. The co-evolutionary dynamic of homophily and learning influences both the topology of the resulting network and the type and distribution of the emergent languages.

## References

- Boguñá, M., Pastor-Satorras, R., Díaz-Guilera, A., & Arenas, A. (2004). Models of social networks based on social distance attachment. *Phys. Rev. E*, 70(5), 056122.
- Centola, D., González-Avella, J. C., Eguíluz, V. M., & San Miguel, M. (2007). Homophily, cultural drift, and the co-evolution of cultural groups. *Journal of Conflict Resolution*, 51(6), 905–929.
- Chambers, J. K. (2003). *Sociolinguistic theory: linguistic variation and its social significance*. Oxford: Blackwell.
- McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology*, 27, 415–444.
- Newman, M. E. J., & Park, J. (2003). Why social networks are different from other types of networks. *Phys. Rev. E*, 68(3), 036122.