Language simulation after a conquest

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Abstract: When a region is conquered by people speaking another language, we assume within the Schulze model that at each iteration each person with probability \( s \) shifts to the conquering language. The time needed for the conquering language to become dominating is about \( 2/s \) for directed Barabási-Albert networks, but diverges on the square lattice for decreasing \( s \) at some critical value \( s_c \).

The language competition model of Abrams and Strogatz assumes the possibility that of two competing languages one has a higher status [1]. We now look for an analogous question in the multi-language Schulze model [2]: Will the language of the conquerors finally always win?

We used the Schulze model with \( F \) features, each of which takes an integer value between 1 and \( Q \). All speakers are positioned on a directed Barabási-Albert network of \( N \) people surrounding a fully connected core of \( m = 3 \) nodes. Each node added to the network selects \( m \) already existing nodes as teachers, via preferential attachment. At each iteration, with probability \( p = 0.5 \) each feature of each node is modified. For this modification, with probability \( q = 0.85 \) the feature value of a randomly selected neighbour (teacher) is taken, while with probability \( 1 - q \) a randomly selected new value between 1 and \( Q \) is taken. Also, at each iteration each speaker with probability \( (1 - x)^2 r \) (\( r = 0.9 \)) gives up the old language and takes over the language of a randomly selected neighbour; here \( x \) is the fraction of the whole population speaking the old language.

Initially the \( N \) people surrounding the core select their own language randomly, while the \( m \) core members select the “central” language where each feature is 2 for \( Q = 3 \) and 3 for \( Q = 5 \). Later, the core members are not subject to the above modifications and represent a “royal family” speaking the unmodified official language. As a result, after a few iterations nearly everybody speaks the central language of the core.

The influence of war is simulated as follows: A foreign power, speaking a language where all features are 1, conquers the country during ten iterations. From then on everybody, including the core, at each iteration with
probability \( s \) adopts the language of the conquerer. The effect of this language shift is particularly drastic on the whole population if a core member shifts to the conquering language. The winning time is defined as the total number of iterations (including the initial ten iterations of war) needed for the conquering language to become the numerically strongest language in the population and for all core members to adopt it.

![Figure 1: Winning time versus adoption probability \( s \), for \( N = 10^4 \).](image)

The deviations for small times come from the initial time of war, 10 iterations, after which the process of adopting the conquering language begins. The straight line gives \( 2/s \).

Fig. 1 shows for three choices of \( F \) and \( Q \) that the winning time is about inversely proportional to the probability \( s \). It seems to be independent of \( N \), Fig. 2. The fluctuations in the winning time are very large and do not seem to diminish if \( N \) increases, Fig. 3. Varying \( p \) at fixed \( q = 0.85 \), or \( q \) at fixed \( p = 0.5 \) does not change much (not shown).

In summary, there seems to be no threshold for \( s \) in the winning times. Even for very small \( s \) the conquering language will win, after a time of the
order of $2/s$. Reality is, of course, more complicated that this model. The Basque language is still used in Northeastern Spain thousands of years after the neighbours started to speak an Indo-European language, while Celtic France mostly started to speak Latin and French only very few centuries after the Roman conquest. Within this model these differences would require that different populations have different probabilities $s$ to adopt the conquering language.

A rather different picture is obtained if we put the speakers on a square lattice instead of the Barabási-Albert network. Then Fig. 4 shows rather small time with little sample-to-sample fluctuations, diverging at some critical value for the probability $s$. (Numerically, divergence means a median time above one million.) Thus perhaps the Basque country in this version had an $s$ below this critical value ever since the Indo-European settlement of the Iberian peninsula, while the $s$ for France was higher.

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**References**

[1] D.M. Abrams and S.H. Strogatz, Nature 424 (2003) 900.

[2] C. Schulze, D. Stauffer, S. Wichmann, Comm. Comp. Phys., submitted.
Figure 3: Distribution of winning times at $s = 10^{-5}$, $F = 8$, $Q = 5$ versus population size $N$.

Figure 4: Winning time versus adoption probability $s$ on square lattices, showing a divergence independent of lattice size. (Median from 5 samples.)