Conquest, Contact, and Convention: Simulating the Norman Invasion's Impact on Linguistic Usage

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ABSTRACT: *Here we simulate the impact of the Norman conquest of 1066 on modern communication strategies. The simulations inject a population of "Normans" into a population of "Anglo-Saxons" situated on a scale-free network and incorporate signaling games with a best-response learning dynamic. Various trials accounted for the assertion by modern historians that the salient systematic division of prestige seen in words of French versus Germanic origin is no accident but rather results from social conditions. The two main veins of exploration account for social context and social structure (i.e. network topology). They also illuminate that the conventions seen in modern English could have gone the other way without appropriate social conditions. In particular, we draw attention to the broad range of applicability of our results and methods to situations of invasive, stable populations integrated into a larger one.*

1. Introduction

English shares cognates with many other languages, notably German and French. The Norman conquest of 1066 radically changed both England's history and its language, infusing new words into the lexicon and creating a divergence in register and context. Consider the differentiation between words for animals and meat; e.g. pork (Fr. *porc*) and swine (Ger. *schwein*). Historians point to social conditions like the lifestyles of the Anglo-Saxon laborers and the French-speaking Norman nobility as the cause of the divergence. But could the results have been different? And what can game-theoretic models or network-centric approaches offer to understand this?

Language contact inevitably means contact between speakers. It not only introduces new words into a lexicon but also can trigger shifts in usage and interpretation, as seen in Table 1. These shifts may release speakers from the computationally burdensome disambiguation process involved with *polysemous* words; their meaning can only be resolved by context. E.g. for the sentences "I fed the rabbit" and "I ate rabbit" the meaning of "rabbit" in the first sentence (the animal itself) and in the second (its meat) is derived by the context.[1] This kind of polysemy is especially apparent for words like *rabbit, goose, shark, fish,* etc., but not for animals like *swine, cow,* and *sheep*, which in general cannot be used for the animal's meat. This is called *partial blocking* (see e.g. Blutner, 2000): the option to construe these words with the animal's meat is blocked by specialized words *pork, beef* and *mutton.* Interestingly, *swine, cow* and *sheep* are of Germanic origin and their today's German counterparts *Schwein, Kuh,* and *Schaf* bear the above-mentioned polysemy.[2]

[1] Obviously the usage as an uncountable or mass noun conveys strong evidence for the concrete meaning (*conceptual grinding* effect), but i) it is not the only evidence and ii) can be seen as a contextual feature.

[2] In fact *Kuh* is an exception, blocked by the German word *Rind*.

Further, *pork, beef* and *mutton* are of French origin; their today's French counterparts are *porc, boeuf* and *mouton.* This suggests the assumption that i) *swine, cow* and *sheep* once bore the animal/meat polysemy and were used in a context dependent way and ii) lost this polysemy by adopting alternative words of French origin, causing the partial blocking. We call this process *emancipation from context dependence.*

All in all, in any case of such a partial blocking instance words of French origin designate the animal's meat, words of Germanic origin the animal itself. This follows a salient trend in the English language: vocabulary of French origin tends to the prestigious, whereas words of Germanic stock often fall into working class topics; i.e. the laboring class has to work (Ger. *Werk*), the upper class gets to play (from Fr. *plaisir* = pleasure). Table 1 shows two different types of systematic division of meaning space between words of Germanic and French origin, next to the animal/meat division a distribution of personal and abstract concepts.

personal	abstract
freedom	liberty
knowledge	science
belief	faith
brotherly	fraternal

animal	meat
swine	pork
cow	beef
sheep	mutton
deer	venison

Table 1: Systematic division of meaning space between words of Germanic and French origin, possibly a result of lifestyle and education differences. The left table shows the division between personal (Germanic origin) and abstract (French origin) concepts. The right table shows the division betweens words for animals and their meat, possibly a result of the French speaking nobility eating the meat of the animals raised by the English speaking workers.

In this article we simulate language contact and its impact on language use by applying signaling games (Lewis, 1969) to social networks. We want to i) simulate the emancipation from context dependence and ii) investigate the social parameters responsible for the salient systematic division of meaning space between words of Germanic and French origin. We proceed by outlining our modifications to the standard signaling game, describing the impact of social context and structure on the adoption of the expected convention, and remarking on the model itself and future directions.

2. Context and Signaling Games

How do conventions arise? Lewis (1969) adressed this in his work *Convention* via *signaling games,* a mathematical model of communication where a sender sends a message to a receiver who then interprets it. When we say conventions, we mean by that a system of coordinated behavior pairing information states with actions; this is typically common knowledge among a group of participants. Examples include driving on the left side of the road in the U.K. or nodding one's head to signal *Yes* in many Western countries. A trip to U.S. will evince the arbitrariness of the driving convention, as will a trip to Bulgaria the nodding one. The nodding example cuts to the heart of our discussion because it reveals a situation comprising coordination over permutations of information, signals, and action. To examine this, we first illustrate a standard signaling game.

2.1 Signaling Games

Consider someone who wants to affirm or negate a proposition. He can nod or shake his head towards his colleague, and his colleague will interpret the gesture with an action. If the interpretation matches the intent of the signal, we can say that the communication was successful. Formally, we can think of this interaction as $G = \langle \{S, R\}, T, M, A \rangle$. S is the sender, R the receiver of the game. T is the set of *topics* the speaker wants to communicate; here $T = \{\text{yes, no}\}$. M is the set of *messages*; $M = \{\text{nod, shake}\}$. Last,$A$ is the set of *actions*; $A = \{\text{yes, no}\}$. Observe that T and A need not be the same, but for simplicity's sake we adhere to that here. There are two properties of the game now to consider: i) the overall structure of the decision process seen in Figure 1 and ii) the potential strategies used by agents in the game, examples of which are seen in Figure 2.

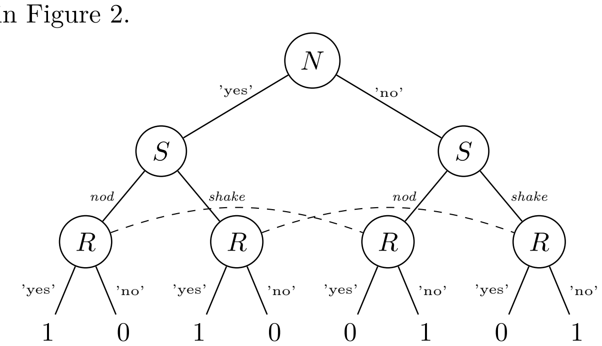

Figure 1: Extensive form game for the standard signaling game's example *nod or shake.*

We assume a base level of rationality in that agents will not choose a strategy with a lower payoff if one with a higher payoff is available. From this, we say the game reaches a *Nash Equilibrium* if agents have no incentive under a given strategy profile to deviate unilaterally from their current strategy. Lewis stated that conventions are such equilibria. In Figure 2, we see that communicative success is more important than the particular convention itself, a principle to keep in mind for the next section. As a general rule, conventions do not merely exist between dyads, but on a societal level. To address this, we delve further into augmenting signaling games with social structure and context.

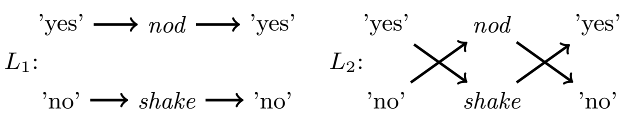

Figure 2: Strategies depicting perfect signaling systems for the standard signaling game's example *nod or shake.*

2.2 Context Signaling Games

Language use is modelled by the *context signaling game* (CSG), a Lewisean signaling game extended by a set of contexts. Such a game is given as $CSG = \langle \{S, R\}, T, L, C, P_T, P_C \rangle$. S is the speaker, R the recipient of the game. T is the set of *topics* the speaker wants to communicate; here $T = \{\text{meat, animal}\}$. L is the *lexicon*, which contains expressions for the appropriate animal. C is a set of different contexts the participants could be in, represented here by $C = \{\text{dinner, farm}\}$. The label *dinner* depicts a context where the topic 'meat' is highly probable; likewise for *farm* and 'animal.' These dependencies are modelled by the *topic probability function* P_T[3]. Finally the *context probability function* P_C depicts the probability of being in a specific context and depends on the speaker's social status $\sigma \in \mathbb{N}$. We assume that the higher the social status of a speaker, the higher the probability that he will be in a dinner context and not in a farm context. With this in mind we defined nine different social statuses from 1 to 9, where a speaker with social status σ is in a dinner context with probability $\sigma/10$ and in a farm context with probability $1 - (\sigma/10)$, as depicted in Table 2.

Status σ	1	2	3	4	5	6	7	8	9
P_C(dinner)	.1	.2	.3	.4	.5	.6	.7	.8	.9
P_C(farm)	.9	.8	.7	.6	.5	.4	.3	.2	.1

Table 2: Speakers social status σ depicts his probability P_C of being in a dinner context or farm context.

A round of such a game between a speaker S and a recipient R can described as follows: nature N chooses a context $c \in C$ with probability $P_C(c)$. Then nature chooses a topic $t \in T$ with probability $P_T(t|c)$. Now speaker S communicates topic t by using an appropriate expression l of his lexicon L. Then recipient R has to construe the received expression l with a topic $t' \in T$. Communication is successful if R reconstructed the topic S had in mind, thus if $t = t'$. Then both participants get a *utility value* of 1, otherwise 0 for miscommunication. Both participants know the given context, but only S knows the given topic. The way a speaker allocates expressions to topics and a recipient allocates topics to expressions is called their *strategy.* Figure 1 depicts the *extensive form* of the CSG with $L = \{\text{“swine”, “pork”}\}$.

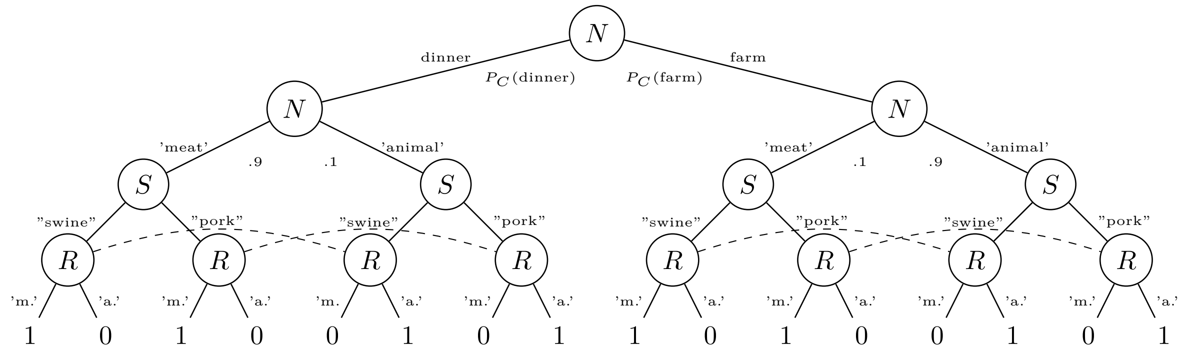

Figure 3: The extensive form of the CSG. (N.B. dashed lines connect situations the recipient cannot distinguish; leaves resulting in 1 depict successful communication.)

[3]The probability function $P_T \in \Delta(T)^C$ returns the probability for $t \in T$ being topic in a context $c \in C$. Here we chose $P_T(\text{meat}|\text{dinner}) = .9$ and $P_T(\text{animal}|\text{farm}) = .9$. Accordingly: $P_T(\text{animal}|\text{dinner}) = .1$, $P_T(\text{meat}|\text{farm}) = .1$.

3. Experimental Set-up & Results

300 agents with a randomly chosen social status and arranged on a social network with *scale-free properties* (Jackson, 2008) played the *CSG* repeatedly as both speaker and recipient with their neighbors on the network. Based on previous encounters, agents choose the *best response* to according to a *belief learning dynamic* (see e.g. Nachbar, 2008). At a simulation's start the agents' lexicons contain only the expression "swine". Right after all agents have learned the same strategy, we simulate the conquest of 1066 by replacing 10% of the agents by Norman invaders, agents whose lexicons contain only the expression "pork". When an agent as a recipient encounters an unknown expression, he adopts it to his lexicon. The simulation ends when every agent's lexicon contains "swine" and "pork" and a unique strategy governs the whole society. In this way we conducted three different experiments, which differ in the conditions of which agents are possible candidates to be replaced. Figures 4, 5 and 6 depict an example of all three experiments.

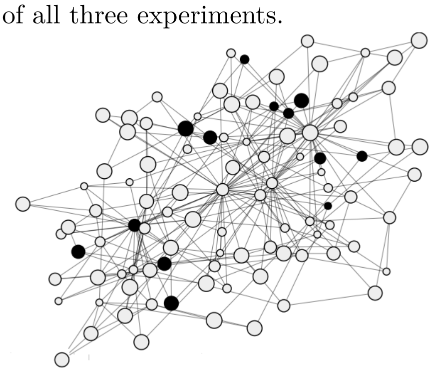

Figure 4: Experiment 1: randomly chosen agents are replaced by Norman invaders (black circles). Note: the larger the circle, the higher the social status.

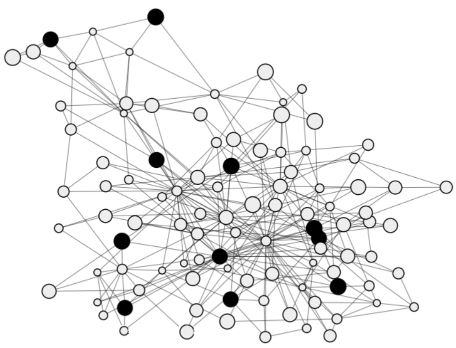

Figure 5: Experiment 2: only agents with a social status higher than a given lower limit are candidates to be replaced. Note: only large circles are replaced by Norman invaders.

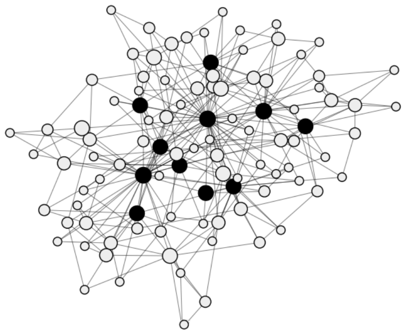

Figure 6: Experiment 3: agents must have a high social status paired with a high degree of centrality (number of neighbors) to be candidates to be replaced. Note: the network features a correspondence of social status and local influence.

3.1 Result 1: Context (In-)Dependence

The agents' initial strategy as a speaker is to use expression "swine" for each topic in each context (it's the only one in the lexicon). As recipient the agents' strategy is context-dependent: in the dinner context they construe "swine" as 'meat', in the farm context as 'animal'. Informally, the agents simply learn that topic 'meat' is more probable in the dinner context and topic 'animal' in the farm context when construing "swine". In Experiment 1 the invasion is done by replacing 30 randomly chosen agents with invaders (e.g. Figure 4). It cause the word "pork" to enter every agent's lexicon, spreading over the society. Every agent learns a new *context-independent* strategy. At the end of each trial every agent has learned one of two possible strategies: S_1 for using the word of French origin for the meat and word of Germanic origin for the animal or S_2, the other way around (Figure 7). Hundreds of simulation runs revealed that i) in each trial only one strategy spreads and stabilizes society-wide and ii) both strategies' emergence is equiprobable. But if it is a question of chance whether S_1 or S_2 emerges, then how can we explain that language use according to S_1 is predominant?

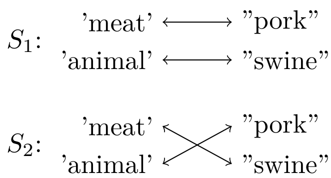

Figure 7: The two strategies S_1 and S_2, whose emergence is equiprobable if the replaced agents are chosen randomly, like in Experiment 1.

3.2 Result 2: Influence of Social Status

In the previous experiment, randomly chosen agents were replaced by invaders. In Experiment 2 and 3, we account for the fact that the Normans probably occupied high social positions in two ways: first by tying social status to context, then to connectivity.

To model the first, in Experiment 2 we consider the social status σ of the replaced agents as follows: we set a lower limit $\beta \in \mathbb{N}$ in such a way that only agents with a social status $\sigma \geq \beta$ could be replaced by invaders. Beginning with Trial 1 ($\beta = 1$) we incrementally increased β stepwise up to Trial 9 ($\beta = 9$) with 300 simulation runs per trial (see e.g. Figure 5 for $\beta = 8$). The simulation results showed: the higher β and therefore the higher the social status of agents replaced by invaders, the higher the probability for the emergence of the expected strategy S_1 (see Figure 8).

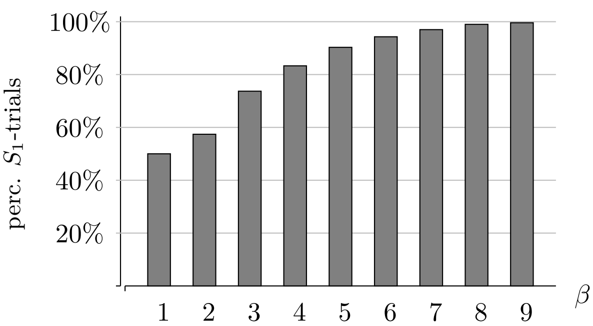

Figure 8: Result of Experiment 2: by increasing the threshold β of the replaced agents, the probability for a society-wide spread of expected strategy S_1 raises.

3.3 Result 3: Influence of Social Structure

For Experiment 3, we attached a second condition to the social status parameter σ, namely a value for the measure of centrality (number of neighbors) d as follows: the higher the social status σ, the higher d and therefore the higher the local influence (see e.g. Figure 6). This aligns with work depicting high status agents as more influential in a society (Nettle, 1999). Interpreting wealth as number of business (or speaking) partners, we derive a rationale for replacing the hubs in the original society with Norman invaders for high β values. We found that this additional parameter accelerated the probability for the adoption of the expected strategy (see Figure 9).

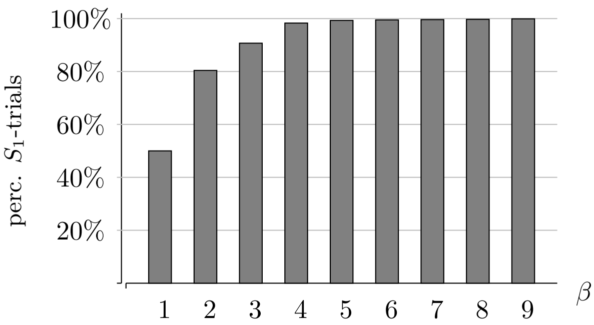

Figure 9: Result of Experiment 3: if the social status σ is also correlated with a higher degree d and therefore a higher local influence, the increasing of threshold β of the replaced agents leads to an accelerated raising of the probability for a society-wide spread of expected strategy S_1.

4. Discussion

Our simulations showed that agents in a social network playing the CSG with only one word in their lexicon resolve its polysemy in a context-dependent fashion. The simulated Norman invasion provided alternatives between words, allowing speakers to distinguish between previously context-dependent meanings. But without further assumptions, the new words could have described any meaning equiprobably. By considering social status and structure, the probability shifted markedly to the expected strategy: the words of the invaders tend towards meanings of upper-class contexts, while the words of the conquered associate more with the lower class.

4.1 Cultural Contact

What does this portend for cross-cultural contact on a more general level and those interested in it? Observe that while these signaling conventions were linguistically motivated, they are more general. Consider first, the signals are costless to learn for the agents. It is the potential for liberation from dependence on context that fosters the new convention. This may not be the case in contact on the ground. Observe also that we are introducing a new signal into an effectively monolexical society, thus effectively doubling the available lexicon. Other research in signaling games (e.g. Mühlenbernd, 2011) details the consequences of more costly signaling approaches.

While the signals are costless to learn, another feature of the model is that there is no inherent dyadic power difference among agents. I.e. the invading agents receive the same penalty for miscommunication as the invaded society. Further experiments into the payoff matrix that best represents an asymmetric dynamic might reveal a different impact on learning the convention. This also recalls that there is no guarantee that the expected convention will emerge without the added social pressure of context or structural placement.

Last, observe that it is not only the invaded population that adopts the convention but also the invaders. Under more stringent conditions, refusal of the invaders to adopt some of the signals of their new society can lead to new, less efficient equilibria.

4.2 Notes on Implementation and Application

While motivated by linguistic history, these results apply to more general phenomena of sociological modeling. We highlight three salient features of the model to that end. First is the Lewisean Signaling Game, a model of communication with applications ranging from linguistics to biology and on scales from bacterial to multi-national. As more permuations of decision spaces and strategies exist to arrive at the game's equilibrium than addressed here, there is great flexibility in implementing such a model. These include potentially infinite type, message, or action spaces; different update dynamics; or message costs.

Second, the interaction protocols do not exist merely between agents, but within them as well. E.g., the update dynamics for the signaling game represent a recognized and tractable implementation of cognitive capacity and theory of mind applied to a dynamic decision process. Various approaches, like those seen in Mühlenbernd (2011), give a more comprehensive view. Underlying this update dynamic is also a risk-neutral calculation procedure. Were the game, as mentioned above, subject to a different payoff matrix, risk aversion might also be a more realistic paradigm to implement.

Last, while the communication and learning of conventions occurs in a dynamic fashion, the overall structure of the network is fixed into a scale-free topology. The choice for this was based on results in data on preferential attachment (Jackson, 2008), something we assume a realistic social network to be a result of. Cultural contact not only brings new conventions or signals into a network, but it also can alter the network's topology or interaction mechanisms. For this reason, a network that included strategic link deletion or formation might also shed new light on the way that a convention spreads through the network through a signaling game.

5. Selected References

Blutner, R. (2000). Some Aspects of Optimality in Natural Language Interpretation. *Semantics, 17(3)*, 189-216.

Jackson, M. O. (2008). *Social and economic networks.* Princeton: Princeton University Press.

Lewis, D. (1969). *Convention.* Cambridge: Harvard University Press.

Mühlenbernd, R. (2011). Learning with Neighbors. *Synthese, 183*, 87-109.

Nachbar, J. (2008). Learning and evolution in games: belief learning. *The new Palgrave Dictionary of Economics.*

Nettle, D. (1999). Using Social Impact Theory to simulate language change. *Lingua, 108*, 95–117.

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