LESS OF THE SAME: MODELING *HORROR AEQUI* AND EXTRAVAGANCE AS MECHANISMS OF NEGATIVE FREQUENCY DEPENDENCE IN LINGUISTIC DIVERSIFICATION

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Two mechanisms involving negative frequency dependence, i.e., pressures for less of the same, have been suggested to affect linguistic evolution: (i) *horror aequi*, a cognitive-psychophysiological effect that leads to avoidance of repetitions, and (ii) extravagance, which is a pragmatic strategy to signal non-conformity and emphasis by avoiding predominant constituents in favor of innovative ones. In this paper, we explore how avoidance biases like this influence the long-term evolution of linguistic constituents. We do so by means of evolutionary analysis of population dynamic models of linguistic diffusion. We show that if individuals are sufficiently sensitive with respect to variation then avoidance biases can yield linguistic diversification, i.e., stable coexistence of constituent variants.

1. Introduction

Linguistic systems exhibit diversity on various levels. Phonological systems consist of diverse sounds, some of which are closely related to each other (e.g., more or less leniated variants of a consonant like /b/). Vocabularies usually consist of thousands of words, some of which may be formally similar but semantically different (e.g., *freak* denoting an abnormal individual or, in fact, an expert or aficionado). Other words are formally different but denote the same concept (e.g., *session* and its slang variant *sesh*). And on the syntactic level, languages feature a multitude of constructions, although some of them are formally slightly different but might fulfill the same function (e.g., [*going to* + V] and [*gonna* + V] for expressing future events), or indeed formally similar but semantically different (e.g., [*going to* + V] and [*going to* + N]). Where does this diversity come from?

One of the potential causes of the successful implementation of variants like the ones above is the tendency to avoid more of the same. We will refer to this as *avoidance bias*. Two mechanisms have been discussed in this matter. On the cognitive-psychophysiological level, the *horror aequi* effect was suggested to promote variation in that it provides a bias against repetitions. On the pragmatic level, *extravagance* was discussed as a mechanism that enhances innovations to make their users stand out of the crowd (Haspelmath, 2000; Walter, 2007; Petré,

2017; Ungerer & Hartmann, 2020). In this paper, we study the effect of such biases on linguistic diversity by means of population-dynamic models. For this, we implement frequency dependent avoidance biases into a dynamical system that characterizes the spread of a linguistic constituent (phoneme, word, construction) through a population of speakers and analyze the long-term evolution of this constituent (Doebeli & Ispolatov, 2010; Dercole & Rinaldi, 2008). We show that diversification of the constituent, i.e., the stable establishment of two variants of itself, depends on the scope of the mechanism and how easy it is for speakers to differentiate between variants.[1]

The subsequent section provides a brief review of the two mechanisms, *horror aequi* and extravagance. After that, we outline our model together with its evolutionary analysis and finally discuss its implications and limitations.

2. *Horror aequi* and extravagance in linguistic evolution

Avoidance biases can operate on different levels. The *horror aequi* effect ('fear of the same') was suggested as a mechanism that lets speakers avoid repetitions of similar (or even identical) linguistic structures operating on various levels of linguistic organization. The effect has been suggested to be motivated by psychological and physiological constraints as well as constraints on cognitive planning (Walter, 2007). In the phonological domain, it was proposed as a mechanism for avoiding repetitions by Brugmann (1917) already in the beginning of the 20th century (e.g., German *Zauberin* rather than *Zaubererin*, where *Zauberer* is a 'male magician' and *-in* is the German feminine suffix). In phonetics and phonology, avoidance biases have been studied under the term *obligatory contour principle*. For instance, Walter (2008) has shown that repetition of the consonants /b, d, g/ leads to the production of lenited variants. In the morpho-syntactic domain, the effect was studied by Rohdenburg and others to account for the avoidance of repeating *-ing* forms in English in sequences like *without bothering to tell him* vs. *without bothering telling him* (Szmrecsanyi, 2008; Rohdenburg, 2011). The effect typically applies within utterances but it can also apply across utterance boundaries, as long as they are temporally close. Indeed, *horror aequi* was suggested to be a potential counterpart of (asymmetric) priming (Jäger & Rosenbach, 2008) and attested experimentally (Hilpert & Saavedra, 2018) (although *horror aequi* was argued by Szmrecsanyi (2008) to be weaker than supportive effects).

Extravagance, in contrast, is a pragmatic phenomenon that by definition applies to interactions among individuals. In an excellent recent review, Ungerer and Hartmann (2020) elaborate on the different aspects of extravagance covered

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[1]In biological evolution, negative frequency-dependent selection is a well-studied mechanism potentially accounting for diversification and stable polymorphism (Brisson, 2018; Chesson, 2000). It is less well studied in cultural evolution; but see, e.g., Doebeli and Ispolatov (2010), who use a model similar to that in this paper to model coexistence of religions.

in the literature. An important aspect of extravagant language seems to be that it lets their users stand out of the crowd. While this may have the reason to signal (out-)group membership (Fajardo, 2019) in a non-conformative fashion (e.g., back-clipping *session* to *sesh* in youth slang), this is not necessarily always the case. Extravagant expressions may be as well used to gain attention or as emphasis device. So, the [*going to* + V] future construction or the progressive construction [*be* V-*ing*] were argued to be motivated by extravagance, as was the lengthened an more explicit expression *by means of* in place of *with* (Haspelmath, 1999, 2000; Vosberg, 2003; Petré, 2017). Length seems to be a particularly relevant property related to extravagance, as seen in phrasal compounds like *make-your-stomach-hurt difficult* (Günther, Kotowski, & Plag, 2020).

What both mechanisms have in common is (i) the tendency to avoid a predominant variant in favor of another variant and (ii) frequency dependence. That is, both *horror aequi* and extravagance only apply if certain structures are used and encountered relatively often. *Horror aequi* requires nearby repetitions of linguistic structures and extravagant expressions require a background of predominantly used forms against which they are perceived as extravagant in the first place. Frequency dependence is negative because avoidance biases impede the usage of the predominant variant. In what follows, we model avoidance biases and their effect on linguistic diffusion through speaker populations.

3. Modeling linguistic evolution under avoidance biases

Let us consider a linguistic constituent that is characterized by a certain property x. Such a constituent could be, e.g., a phoneme, a phoneme sequence, a word, or a construction, and its property x could be some formal aspect (such as the degree of lenition of the consonant /b/) or some semantic aspect (like the sentiment of the word *freak*, which could be positive, negative, or something in between). We assume that x can be measured on a continuous scale, i.e., $x \in \mathbb{X} \subseteq \mathbb{R}$, where $\mathbb{X}$ is an interval defining the range of possible values. By learning the constituent, it is transmitted from one individual to the next, either horizontally, or vertically in first-language acquisition. Whenever a user of the constituent and a learner who does not yet know it meet, successful learning takes place at an intrinsic rate λ depending on x. We also assume that learning is optimal for some value x_0 (i.e., f is locally concave around x_0). When an individual learns the constituent, they switch from the learner to the user class. Let L and U denote the respective number of individuals.

Individuals can also cease to use a constituent so that they switch from the user class back to the learner class. In our model, switching back to the learner class is motivated by avoidance biases outlined before. Thus, users cease to use a constituent whenever they interact with another user of that constituent at an avoidance rate α. That is, growth is subject to negative frequency dependence (Brisson, 2018). Oftentimes, individuals using slightly different variants will interact. Sup-

pose that the values x and y define two different variants of a constituent (two different degrees of lenition; two different sentiment values). We assume that α is a decreasing function of the distance $\Delta = |x - y|$ between both variants obtaining its maximum α_0 at $\Delta = 0$. Avoidance rate α is highest if both variants are identical and decreases the more different they are. A function that models such a behavior is

$$\alpha(\Delta) = \alpha_0 \exp(-1/2 \cdot \Delta^2/\sigma^2). \tag{1}$$

This is a bell-shaped curve depending on Δ. The steepness of this curve is determined by the parameter σ, which stands for the *scope* of the avoidance mechanism. The scope defines the range of values that are affected by that mechanism in a fuzzy manner (Figure 1a, top panel). If σ is high (flat curve) then even substantially different variants lead to high mutual avoidance rates. If σ is low (steep curve) then only relatively similar constituents will lead to high avoidance rates. The reciprocal $1/\sigma$ can be interpreted as a measure of the *sensitivity* with respect to variation. High sensitivity (low σ) means that only nearby variants are perceived as identical. Low sensitivity (high σ) means that most variants are perceived as identical, which promotes avoidance. Note that, for simplicity, our model only captures mechanisms of negative frequency dependence although language clearly shows positive frequency dependence as well; see Doebeli (2011) for a model juxtaposing conformity and non-conformity biases. We will come back to this limitation in the final section.

Given the above considerations, the population dynamics of a constituent specified by x, in the absence of other variants, is given by the differential equation

$$\dot{U} = \lambda(x)UL - \alpha_0 UU, \tag{2}$$

where we assume that population size is normalized so that $L + U = 1$. If $\lambda(x) > 0$ (positive learning rate) the population dynamic equilibrium is given by $\hat{U}(x) = \lambda(x)/(\lambda(x) + \alpha_0)$.

What can we say about the long-term evolution of the constituent's property x? We can model the evolutionary trajectory of x with the help of the canonical equation of adaptive dynamics (Meszena, Kisdi, Dieckmann, Geritz, & Metz, 2002; Dercole & Rinaldi, 2008), which relates to the Price equation (Page & Nowak, 2002) and defines the rate of change of x as

$$\dot{x} = M\frac{\Sigma^2}{2}\hat{U}(x)\frac{\partial f(x,y)}{\partial y}\bigg|_{y=x}. \tag{3}$$

Here, the constants M and Σ^2 define the rate and variance of linguistic innovations, respectively. More importantly, $f(x,y)$ denotes invasion fitness, i.e., the exponential growth rate of a rare variant characterized by y in a population in which x is the predominant variant. That is, for every x, $f(x,y)$ defines a fitness

landscape that rare variants y have to cope with (Figure 1a, mid panel). Given the population dynamics in (2), invasion fitness can be derived as

$$f(x, y) = \lambda(y)(1 - \hat{U}(x)) - \alpha(y - x)\hat{U}(x). \tag{4}$$

One can show that x_0 (where learning is optimal) defines an equilibrium of the evolutionary dynamics (3) (Doebeli & Ispolatov, 2010). Moreover, x_0 is an evolutionary attractor, so that values close to x_0 are driven towards this equilibrium.

What is more interesting is this: if σ is large (low sensitivity with respect to variation) then x_0 is a local maximum of the fitness landscape given by $f(x_0, y)$ (Figure 1a, bottom panel). This can be seen by looking at the curvature of f around x_0 (because $\alpha''(0)$ is small for large σ):

$$\left. \frac{\partial^2 f(y, x_0)}{\partial y^2} \right|_{y=x_0} = \lambda''(x_0)(1 - \hat{U}(x_0)) - \alpha''(0)\hat{U}(x_0). \tag{5}$$

This means that x_0 cannot be invaded by nearby variants. If, however, σ is sufficiently small then x_0 is a local minimum of the fitness landscape $f(x_0, y)$, so that x_0 can be invaded by nearby variants. Thus, x_0 is a *branching point* at which the population is split into two variants that stably coexist (Geritz, Metz, Kisdi, & Meszéna, 1997). This is shown in Figure 1b. High sensitivity with respect to variation combined with avoidance biases leads to diversification of the constituent into two variants (e.g., more/less lenited; positive/negative).

4. Discussion and conclusion

We have seen that mechanisms accounting for negative frequency dependence can drive linguistic diversification. Two such mechanisms have been discussed: (i) the *horror aequi* effect operating on the cognitive-psychophysiological level and (ii) extravagance, i.e., the tendency to behave differently in order to stand out as a pragmatic phenomenon. In the literature, both mechanisms have been suggested to promote linguistic innovations and hence linguistic evolution. What we have shown in our contribution, though, is that stable coexistence of two variants (i.e., diversity) that result from one of these mechanisms depends on how sensitive individuals are with respect to variation. If individuals do not differentiate between different variants and put all of them into one basket then neither *horror aequi* nor extravagance will lead to diversification. Both mechanisms require a certain ability to differentiate between variants. Without this ability, linguistic evolution simply optimizes learnability (so that, say, only lenited /b/ and *freak* with a positive connotation would remain).

Why is this plausible? If (i) individuals treat almost all variants as identical then *horror aequi* is very likely to apply. If, however, *horror aequi* only applies to very similar variants, the mechanism will lead to deletion much more rarely, hence enforcing coexistence. Likewise, if (ii) even distant variants are considered the
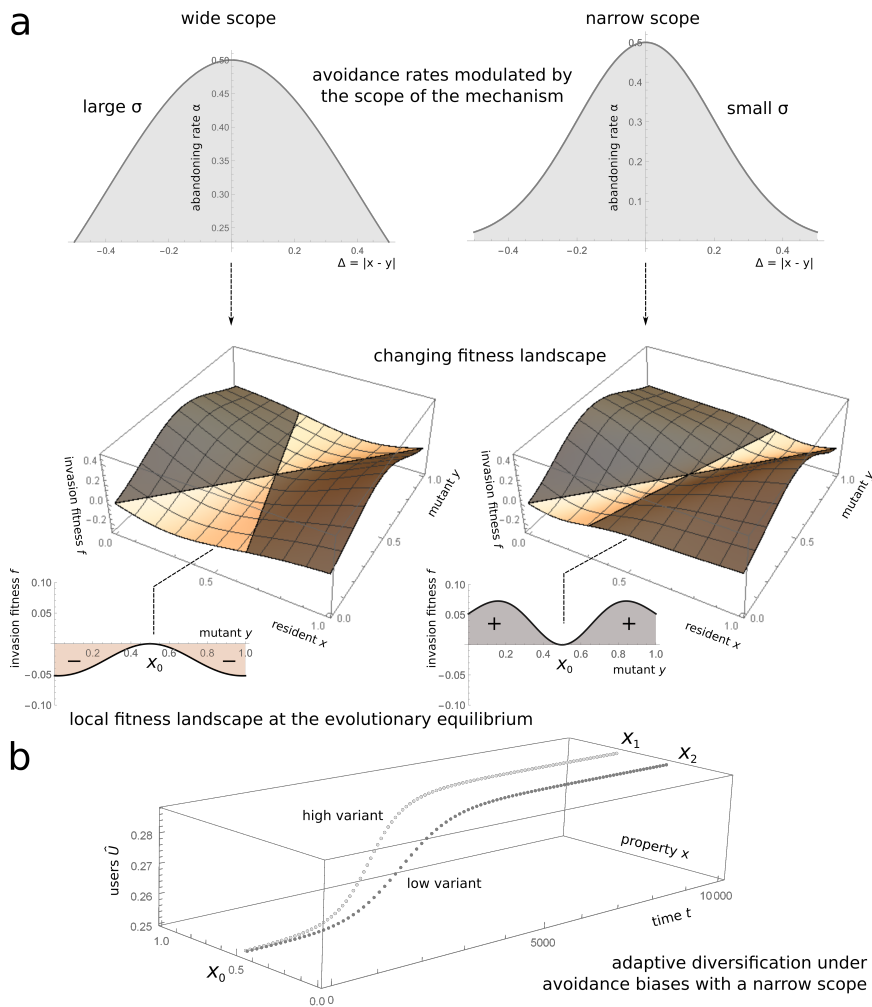
Figure 1. (a) Evolutionary dynamics for wide (left, $\sigma = 0.4$) and narrow (right, $\sigma = 0.2$) scopes. Top panel: avoidance rates α are modulated by the scope of the mechanism. Mid panel: changing fitness landscape showing invasion fitness $f(x, y)$ for all combinations of a predominant variant ('resident') characterized by x and a rare variant ('mutant') characterized by y. Dark regions denote positive, and light regions negative invasion fitness. In both cases, x_0 is an evolutionary *attractor*. This is because below/above x_0, mutants closer to x_0 than the resident have positive invasion fitness, so that x is driven towards x_0. Bottom panel: Fitness landscapes of the mutant variant y in an environment set by the resident $x_0 = 0.5$ at the evolutionary equilibrium. In the right case, x_0 is a minimum of the fitness landscape, can be invaded by nearby variants and is hence a *branching point*. (b) Diversification into two variants if the underlying avoidance mechanism has a narrow scope (small σ). NB: the symmetry in (b) is a direct consequence of the symmetry of $\lambda(x)$ in the present model which we assume for simplicity (the shape of $\lambda(x)$ can be more complex, of course). The same holds true for the location of x_0 which we simply assume to be 0.5 in this simulation.

same, they will be dropped in order to behave in an extravagant way. But if individuals have a very fine-grained perception of different variants and can tease them apart easily then they will stick to their own behavior because, after all, it is then more likely to be judged as extravagant by others. Thus, fine-grained perception of formal and semantic differences between linguistic constituents which—*given the mechanisms discussed here*—can ensure the diversity of linguistic (phonological, lexical, constructional) inventories.[2]

The model proposed in this paper clearly is simplistic. It builds on homogeneous mixing, simple population structure, and the technical assumption that linguistic properties evolve gradually (in other words, that changes are small and that innovations spread fast). Most importantly, it only explicitly features mechanisms of negative but no mechanisms of positive frequency dependence, respectively, such as conformity biases (on the pragmatic level), priming effects (on the cognitive-psychophysiological level), or simplicity preferences inducing positive frequency dependence. Obviously, such mechanisms exist as well and shape linguistic evolution (Jäger & Rosenbach, 2008; Enfield, 2008; Baumann & Sommerer, 2018). Our point is not that avoidance biases are *necessary* for explaining linguistic diversity. The point is that, everything else being equal, mechanisms of negative frequency dependence can yield interesting evolutionary dynamics in that they represent *sufficient* conditions for linguistic diversification.

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[2]As a corollary, populations with impeded perceptive sensitivity (for whatever reason, be it environmental, technological, or, thinking of language evolution on the biological time-scale, physiological or cognitive) should accommodate less diverse inventories.

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