Abrupt and Gradual Sound Change in an Expanding Lexicon*

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Abstract

The sound structure of language changes over time, but the process of change is not well understood. Sound change appears to occur abruptly as well as gradually, but it is not clear why, and it is not clear how the different rates of change affect the sound structures that emerge. This paper advances two hypotheses to answer these questions: (1) The Rate Hypothesis suggests that change occurs abruptly or gradually depending on how much an existing system is destabilized by social and cultural forces. (2) The Variation Hypothesis suggests that a greater diversity of sound structures emerge from abrupt change than gradual change because selection occurs on larger amounts of variation in more destabilized systems. These two hypotheses were tested in a computational model of sound change. The simulation results confirmed the hypotheses, and further suggested that abrupt change initially results in functionally suboptimal structure, whereas gradual change preserves good functionality. Overall, the study explains different rates of change in terms of a single framework and resolves a paradox in historical linguistics in which abrupt and gradual change are seen as incompatible, yet both exist.

1 INTRODUCTION

The pronunciation of words in a given language changes over time. This process, known as sound change, begins when speakers start pronouncing words with similar sound structures differently. Over time, several pronunciations coexist; eventually a single new pronunciation becomes the standard for a particular word class in a lexicon, completing the change. A well-known example of sound change is Grimm's Law, which formalizes the First Germanic Consonant Shift (Hock, 1991). As part of this shift, most instances of Proto-Indo-European voiceless stops were changed into Germanic voiceless fricatives. Accordingly, Germanic words differ predictably from their Romance language counterparts, which did not undergo the same sound change. For instance, compare the Latin words *piscis*, *pater*, *tres* with the English equivalents *fish*, *father*, *three*. This example also demonstrates why sound change is important—it is one of the major ways in which languages differentiate over time. In order to understand how different sound systems emerge, it is important to understand the process of sound change.

Sound change appears to be systematic, in that a particular change affects all eligible words in a lexicon (McMahon, 1994). It is not known, however, how this process takes place. A group of 19th century German linguists, called the Neogrammarians, originally proposed that sound change occurs abruptly across the lexicon. This view is still accepted by many linguists (e.g. Hock, 1991; Labov, 1994). In contrast, others have argued that sound change spreads gradually across the lexicon (e.g. Chen & Wang, 1975; Krishnamurti, 1978). The same language data is sometimes used to support each hypothesis. For instance, the English Great Vowel Shift, which brought about a series of vowel changes in Early Modern English, is used as an example of gradual change (Ogura, 1987; Aitchison, 1991) as well as abrupt change (Hock, 1991; Labov, 1994). So, the argument over whether sound change occurs abruptly or gradually presents a paradox: "both (views) are right, but both cannot be right (Labov, 1981: 269)."

The paradox leads to two main problems for understanding the process of sound change: (1) why does sound change proceed at different rates; and (2) what effect do the different rates have on the structure that emerges. In the present paper, we address these problems by developing a model of sound change, based on an analogy between linguistic and biological change. The model assumes that destabilizing, social and cultural pressures of variable strengths stimulate variation, and that new sound structures are selected from that variation according to the functional

*The University of Texas at Austin, Artificial Intelligence Laboratory, Technical Report AI01-289

pressures of articulatory ease and perceptual distinctiveness. This model leads to two hypotheses, addressing each of the above problems: (1) Strong destabilizing pressures induce abrupt change, whereas weak pressures induce gradual change. (2) Strong destabilizing pressures induce more variation than weak pressures, giving rise to a greater diversity of structures.

The above hypotheses, identified as the Rate and Variation Hypotheses, were tested in simulations in which we manipulated the strength of a destabilizing pressure on an evolving lexicon. Simulation results supported the hypotheses. Strong and weak destabilizing pressures induced abrupt and gradual change, respectively. The changed lexicons differed in structure depending on whether they emerged abruptly or gradually. In addition, the results suggested that abrupt sound changes are initially suboptimal (under the functional pressures), whereas gradual changes maintain good functionality. Overall, these results support a new model of sound change—one that explains why sound change occurs at different rates, and how abrupt and gradual change can be distinguished. In the next two sections, we develop the model in detail, followed by simulations, results, and comparisons to other theories of sound change.

2 SOUND CHANGE

Explanations of language change have often been inspired by evolutionary theory (McMahon, 1994; Croft, 2000). In biological evolution, morphological or behavioral traits such as height or eating habits vary in a population of organisms. Changes in environmental or social (sexual) factors may favor a less well represented variant of a trait over a more highly represented one. For instance, if the environment suddenly changed so that the only food source available was tree foliage, the tallest individuals in a population would be favored over individuals of average height. Change occurs over generations as the new variant of a trait becomes highly represented and the mean character of the population shifts. Thus, the process of biological change can be understood as selection operating on variation.

Sound change can also be explained this way; however, since language is a cultural organism, variation and selection must be defined in social terms (Croft, 2000). In sound change, the way a sound sequence is produced varies from speaker to speaker. Changes in social or cultural factors may encourage a community of speakers and listeners to favor a new variant in production over a standard one. Sound change occurs when the new variant replaces the standard pronunciation, thereby shifting the sound structure of the lexicon. In this way, the process of sound change is analogous to evolution by natural selection.

Below, we develop this view of language change further to address the problems raised by the paradox of sound change. We look more closely at how language change is initiated and how structure emerges, aiming to explain why sound change proceeds at different rates and what effects, if any, rate of change has on the structure of a sound system.

2.1 Initiating Change: Variable Pressures

The main reason for language change is analogous to the reason for biological change: the social environment is constantly changing. Such a dynamic environment creates instability, which provides the impetus for language change (Steels & Kaplan, 1998; Nettle, 1999; Dircks & Stoness, 1999).

Linguists have identified a number of forces that create instability (for an overview, see Aitchison, 1991). We call these forces variable pressures and categorize them into two main types: sociolinguistic and expansion pressures. Sociolinguistic pressures destabilize language when the social structure of a society undergoes change, for instance, when group identity is forged or changed. Expansion pressures create new lexicons and occur with cultural change, for instance, with technological innovation or word borrowing. Either pressure will force language into disequilibrium, initiating language change.

2.2 Emergent Structure: Constant Pressures

A new sound structure emerges as equilibrium is restored through social selection, which can be influenced by many factors including prestige, identity, or language contact (Fasold, 1984; Edwards, 1985). The most fundamental factor influencing social selection arises from the function of language, that is, the need to communicate effectively (Martinet, 1955; Lindblom, MacNeilage, Studdert-Kennedy, 1984; Steels, 1997): (1) sounds must be easy to articulate; and (2)

they must be perceptually distinctive. Functional pressures apply in the same way for all speakers of all languages, and do not change over time.

Models of emergent sound structure have shown that cross-language regularities can be explained in terms of either articulatory ease or perceptual distinctiveness or both (e.g., Liljencrants & Lindblom, 1972; Joanisse & Seidenberg, 1997; de Boer, 1999, Oudeyer, 2001; Redford, Chen, Miikkulainen, 2001). Language differences are also consistent with these functional pressures. This is because articulatory ease and perceptual distinctiveness often conflict with one another and so define a complex optimization problem that different sound structures may solve equally well (Redford, Chen, Miikkulainen, 2001). In other words, different languages arise as equally good solutions to the same optimization problem.

2.3 The Process of Change: Selection on Variation

The variable and constant pressures on a system are independent, but linked through variation. Variable pressures amplify normal (accidental) variation and introduce new variation, affecting both the rate and structure of sound change. The effect on the rate is proposed as the Rate Hypothesis. The effect on the structure is proposed as the Variation Hypothesis.

2.3.1 Rate Hypothesis

The Rate Hypothesis suggests that the rate of sound change depends on the strength of the variable pressure that destabilizes the sound system. In a destabilized system, structure is less evident than variation. Depending on the strength of the pressure, the system is destabilized to a greater or lesser extent. In the extreme, a strong variable pressure will cause the existing structure to be obscured by variation. Under these conditions, new structure emerges de novo with few constraints, and sound change is abrupt. In the other extreme, a weak pressure will allow the existing structure to remain evident despite variation. Emergent structure is additionally constrained by the pre-existing structure, and sound change is gradual, as new forms are slowly selected over old ones. This way sound change occurs either abruptly or gradually through the same process.

2.3.2 Variation Hypothesis

The Variation Hypothesis suggests that a greater diversity of sound structures emerge from an abrupt change than from a gradual change. This is because variable pressures affect the amount of variation available for selection, which in turn affects the number and types of structures that can emerge. For example, a strong pressure for upward social mobility causes lower-middle and upper-working class British English speakers to hypercorrect their speech and introduce new variants into their language. Lower-working class speakers are unaffected by such a pressure (they are not socially mobile) and do not introduce these types of variants (McMahon, 1994: 244). A larger amount of variation allows a greater diversity of sound structures to emerge because more different variants are available for selection, and many different structures will satisfy the functional constraints equally well (Redford, Chen, Miikkulainen, 2001). So, abrupt change can be distinguished from gradual change on the basis of the diversity of structures that emerge.

In this paper, we test the Rate and Variation Hypotheses in a computational model of sound change, called the Lexicon Expansion Model (LEM). A single lexicon is evolved according to constant and variable pressures, thereby simulating the conditions of language change over time, as will be described in the next section.

3 LEXICON EXPANSION MODEL (LEM)

The Lexicon Expansion Model (LEM) first evolves a population of syllables according to the constant pressure for articulatory ease. Once a syllable population is established, syllables are randomly selected and concatenated to form words of differing lengths. A number of words are combined to form an initial lexicon, which is evolved according to the constant pressure for perceptual distinctiveness.