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Evidence for a learning bias against saltatory phonological alternations

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ABSTRACT

This study provides new experimental evidence that people learn phonological alternations in a biased way. Adult participants were exposed to alternations between phonetically dissimilar sounds (i.e., those differing in both voicing and manner, such as [p] and [v]). After learning these alternations, participants assumed, without evidence in the input, that more similar sounds (e.g., [b] and [v]) also alternated (Exp. 1). Even when provided with explicit evidence that dissimilar sounds (e.g., [p] and [v]) alternated but similar sounds ([b] and [v]) did not, participants tended to make errors in assuming that the similar sounds also alternated (Exp. 2). By comparison, a control group of participants found it easier to learn the opposite pattern, where similar sounds alternated but dissimilar sounds did not. The results are taken as evidence that learners have a soft bias, considering alternations between perceptually similar sounds to be more likely.

1. Introduction

A phonological alternation occurs when a form is pronounced differently depending on its phonological context. In American English, for instance, the verb root *pat* is pronounced with a final [t] in the word *pats* [pæ**t**s] but with a tap sound [ɾ] in the word *patting* [pæɾɪŋ]. Native speakers of English know that the words *pats* and *patting* are related to the same verb root *pat* even though the root itself is pronounced differently in the two words. More generally, adult speakers tacitly know the distribution of phonological variants in their language and they are able to map multiple surface variants to the same representation at an abstract level (Lahiri & Marslen-Wilson, 1991). Learning the alternations of one's language must therefore be part of the language acquisition process, but there have been few studies directly looking at how they are learned.

Part of the process of acquiring such phonological mappings likely involves tracking statistical properties of the linguistic input. Distributional learning is undeniably a powerful tool available to the language learner. Research has indicated that it plays a role in several aspects of early phonological acquisition, including discrimination of speech sounds (Anderson, Morgan, & White, 2003; Maye, Werker, & Gerken, 2002), phonotactic learning (Chambers, Onishi, & Fisher, 2003), and word segmentation (Saffran, Aslin, & Newport, 1996). Indeed, 12-month-old infants can learn novel alternations in an artificial language based solely on distributional information (White, Peperkamp, Kirk, & Morgan, 2008).

A plausible starting point for learning alternations is by looking for complementary distributions among speech sounds, that is, by looking for cases where two speech sounds never occur in the same phonological environment (e.g., Peperkamp, Le Calvez, Nadal, & Dupoux, 2006). For instance, infants exposed to English may notice that [t] and [ɾ] never occur in the same environment, leading them to analyze the two sounds as alternating variants of the same phoneme. However, this process is unlikely to be based on distributional information alone. In English, for instance, the sounds [h] and [ŋ] happen to have completely non-overlapping distributions because [h] only occurs at the beginning of syllables (as in [hæt] *hat*) and [ŋ] only occurs

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at the ends of syllables (as in [sɪŋ] *sing*). No phonological analysis, however, would claim that [h] and [ŋ] are context-dependent variants of the same underlying sound because, other than being consonants, the two sounds are phonetically distinct in almost every possible way (Trubetzkoy, 1939/1969, pp. 49–50; see Peperkamp, Le Calvez, et al., 2006 for a similar case in French).

If learning which sounds alternate involves more than just tracking their distributions, which biases play a role in constraining this learning? The current study focuses on one way in which distributional learning might be constrained according to the similarity of the sounds involved. In the remainder of this section, I will first discuss the potential role of similarity in learning alternations and introduce the principle of minimal modification (Section 1.1). I will then define saltatory alternations and explain why they represent a counter-example that is problematic for phonological theory (Section 1.2). Finally, this section will conclude with a brief introduction to two experiments designed to test for a learning bias against such alternations (Section 1.3).

1.1. The principle of minimal modification as the basis for a learning bias

Languages differ in which alternations they allow, yet we see that some alternations occur commonly across languages whereas other possibilities are uncommon or even unattested. It has long been noted that alternations between dissimilar sounds are uncommon relative to alternations between more similar sounds (e.g., see Trubetzkoy, 1939/1969). Steriade (2001/2008) expressed this principle in terms of *minimal modification*, arguing that alternations typically result in variant forms that are minimally different from each other, perceptually speaking. For example, many languages, such as German, do not allow voiced obstruents at the ends of words (where obstruents are sounds with a high degree of constriction in the oral tract, such as stops and fricatives). Such restrictions have a functional aerodynamic explanation because it is difficult to sustain the subglottal pressure necessary to maintain voicing in word-final obstruents (see Kirchner, 1998, pp. 56–57; Westbury & Keating, 1986). Steriade shows that in languages with such restrictions, word-final voiced obstruents are overwhelmingly "repaired" by being devoiced rather than by being deleted, nasalized, moved, etc. She provides evidence that devoicing represents the minimal perceptual change for voiced obstruents in that position.

Because of this cross-linguistic tendency for minimal modification, Steriade (2001/2008) has proposed that humans approach the language learning process with an *a priori* bias, which causes learners to assume that alternations between highly similar sounds are more likely than alternations between dissimilar sounds. This bias acts in a scalar way: the more similar the sounds, the better the alternation. Underlying this bias, Steriade proposes, is an implicit awareness on the part of learners, possibly based on their prior experience, of the relative perceptual similarity between pairs of sounds in any given phonological context. They can draw upon this mental representation of relative similarity, which she calls the perceptibility map (P-map), to facilitate their learning of phonological patterns.

Two studies provide experimental evidence that language learners are indeed sensitive to the similarity of sounds when learning novel alternations. Skoruppa, Lambrechts, and Peperkamp (2011) trained adults on arbitrary alternations between sounds differing in one, two, or three phonological features. They found that alternations between sounds differing in only one feature (e.g., [p ~ t]) were more quickly learned and more readily extended to new words of the same type relative to the other alternations. There was no difference in learning, however, for alternations between sounds differing in two features (e.g., [p ~ s]) and those differing in three features (e.g., [p ~ z]). These results suggest that learners find alternations between highly similar sounds easier to learn, but the effect of similarity beyond a single feature remains unclear.

Wilson (2006) used a different artificial language paradigm. Participants were trained on novel alternations involving palatalization, with one group learning that it occurred before high vowels (e.g., [ki] → [tʃi]) and a different group learning that it occurred before mid vowels (e.g., [ke] → [tʃe]). Velar stops are more acoustically and perceptually similar to palato-alveolar affricates before high vowels than before mid vowels (e.g., [ki] and [tʃi] are more similar than [ke] and [tʃe]). When each group was later tested on the cases that were not presented during training, the results suggested an asymmetry in generalization. The high vowel group ([ki] → [tʃi]) only rarely generalized the alternation to the mid vowel context ([ke] → [tʃe]) where the alternating sounds were less similar to each other. In comparison, the mid vowel group ([ke] → [tʃe]) was more willing, relatively speaking, to generalize to the high vowel context ([ki] → [tʃi]) where the alternating sounds were more similar to each other. With the support of a computational model, Wilson suggested that phonetic similarity was responsible for the observed asymmetry in degree of generalization (but see Moreton & Pater, 2012, for potential problems with the interpretation of these results).

The current study takes a novel approach to investigating the role of similarity in phonological learning. It focuses on a specific type of alternation, called a saltatory alternation, which represents a striking counterexample to the principle of minimal modification proposed by Steriade and others. The experimental results presented below demonstrate a clear case where learners respond in a way that is not based solely on their input, but is consistent with a learning bias based on the principle of minimal modification.

1.2. Saltatory phonological alternations: A case of excessive modification

A *saltatory alternation*[1] refers to a phonological alternation in which an intermediate, non-alternating sound must

[1] The term "saltatory" (from Latin *saltus* 'leap') is borrowed from Lass (1997, chap. 5), who used it to refer to similar types of "jumping" diachronic sound changes. Similarly, Minkova (1991) has used the term "leapfrogging", as well as the term "saltatory" (p. 222), to refer to such sound changes.