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Biased generalization of newly learned phonological alternations by 12-month-old infants

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ABSTRACT

Previous work has suggested that learners are sensitive to phonetic similarity when learning phonological patterns (e.g., Steriade, 2001/2008; White, 2014). We tested 12-month-old infants to see if their willingness to generalize newly learned phonological alternations depended on the phonetic similarity of the sounds involved. Infants were exposed to words in an artificial language whose distributions provided evidence for a phonological alternation between two relatively dissimilar sounds ([p ~ v] or [t ~ z]). Sounds at one place of articulation (labials or coronals) alternated whereas sounds at the other place of articulation were contrastive. At test, infants generalized the alternation learned during exposure to pairs of sounds that were more similar ([b ~ v] or [d ~ z]). Infants in a control group instead learned an alternation between similar sounds ([b ~ v] or [d ~ z]). When tested on dissimilar pairs of sounds ([p ~ v] or [t ~ z]), the control group did not generalize their learning to the novel sounds. The results are consistent with a learning bias favoring alternations between similar sounds over alternations between dissimilar sounds.

1. Introduction

Research suggests that infants track the distribution of speech sounds in their language input from an early age and use this information to accomplish a variety of linguistic tasks – discriminating speech sounds (Anderson, Morgan, & White, 2003; Maye, Werker, & Gerken, 2002), learning phonotactics (Chambers, Onishi, & Fisher, 2003), and segmenting words from running speech (Saffran, Aslin, & Newport, 1996). However, many have proposed that phonological learning is biased, such that not all patterns are equally learnable. To determine which biases might be playing a role during phonological acquisition, we must look for cases where infants either (a) fail to learn patterns available in their input (or learn some patterns more slowly than others) or (b) generalize their learning in ways that are not predicted from the input alone. In this paper, we test for the latter.

One bias with ample support in the literature is that complex patterns are more difficult to learn, and less readily generalized, than simpler patterns (adults: Pycha, Nowak, Shin, & Shosted, 2003; Skoruppa & Peperkamp, 2011; infants: Chambers, Onishi, & Fisher, 2011; Cristià & Seidl, 2008; Saffran & Thiessen, 2003; for an overview see Moreton & Pater, 2012a). A more controversial proposal (see Moreton & Pater, 2012b) is that learners prefer patterns with an underlying phonetic motivation, sometimes called a substantive bias (e.g., Wilson, 2006). Under some accounts, learners are biased against "unnatural" or "marked" patterns due to universal grammatical constraints on learning (e.g., Prince & Smolensky, 1993/2004; Tesar & Smolensky, 2000). However, infant studies looking for markedness biases have produced mixed results, with

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some providing support (Jusczyk, Smolensky, & Allocco, 2002) and others finding no effect (Seidl & Buckley, 2005).

Another type of substantive bias proposed is that learners prefer phonological processes involving small phonetic changes. Evidence for such a bias has come from language typology (Steriade 2001/2008), artificial language experiments with adults (Skoruppa, Lambrechts, & Peperkamp, 2011; White, 2014; Wilson, 2006), and computational modeling (Peperkamp, Le Calvez, Nadal, & Dupoux, 2006; White, 2013; Wilson, 2006). In this study, we investigated whether 12-month-old English-learning infants' willingness to generalize newly learned phonological alternations is biased in favor of alternations involving phonetically similar sounds.

Phonological alternations occur when surface forms vary systematically depending on their phonological context. For example, in American English the final [t] in *pat* [pæ**t**] is pronounced as a tap sound [ɾ] in *patting* [pæɾɪŋ]. Our testing paradigm and stimuli were based on White et al.'s (2008) study showing that 12-month-olds can learn novel alternations after brief exposure to an artificial language. In their study, infants were exposed to [p] only after consonants and [b] only after vowels (e.g., *rot pevi, na bevi*...), but [s] and [z] appeared after both consonants and vowels. At test, infants preferred listening to novel word pairs beginning with p/b (e.g., *poli*/*boli*) compared to pairs beginning with s/z (*sadu*/*zadu*), presumably because *poli* and *boli* were treated as alternating variants of the same word whereas *sadu* and *zadu* were interpreted as distinct words. Infants exposed to the opposite distribution showed the opposite preference at test.

Using a modified version of White et al.'s (2008) design, we exposed infants to alternations involving either pairs of dissimilar sounds (Bias condition) or pairs of similar sounds (Control condition). Unlike White et al. (2008), we then tested infants on novel pairs of sounds that were more similar (Bias condition) or less similar (Control condition) than the alternating sounds heard during exposure. If infants have a bias to prefer alternations between similar sounds, then we expected generalization from dissimilar to similar sounds (Bias condition), but not from similar to dissimilar sounds (Control condition).

2. Experiment

2.1. Method

2.1.1. Participants

Forty 12-month-olds (26 males, mean age = 370 days, age range = 349–407 days) participated. All had more than 85% input in English based on a parental language questionnaire (Bosch & Sebastián-Gallés, 2001; Sundara & Scutellaro, 2011). Eleven additional infants were tested but excluded due to crying ($n = 9$), experimenter error ($n = 1$), or equipment problems ($n = 1$).

2.1.2. Design and stimuli

Infants were randomly assigned to either the Bias condition or the Control condition. In the Bias condition, we exposed infants to alternations involving dissimilar sounds (i.e., sounds differing in two features: voicing and continuancy): [p ~ v] or [t ~ z]. Infants heard phrases consisting of a monosyllabic "function" word (*na* or *rom*) followed by one of sixteen CVCV "content" words (e.g., *rom poli*). For each infant, sounds at one place of articulation (labials or coronals) were in complementary distribution; voiced fricatives (e.g., [v]) only appeared after *na* and voiceless stops (e.g., [p]) only appeared after *rom*, thus providing evidence for a phonological alternation. Sounds at the other place of articulation ([t] and [z]) appeared after both *na* and *rom*, meaning they were contrastive (i.e., not predictable from context and thus able to differentiate words). Infants were divided into two sub-groups, depending on whether they learned the [p ~ v] alternation (Labial sub-group) or the [t ~ z] alternation (Coronal sub-group). In the Control condition, infants were instead exposed to alternations between similar sounds (i.e., sounds differing only in continuancy): either [b ~ v] or [d ~ z] depending on sub-group. For illustration, sample stimuli are provided in Table 1.

Previous results (White et al., 2008) suggest that infants hearing [p] and [v] in complementary distribution (as in the Labial sub-group of the Bias condition) will assume that *puni* and *vuni* are context-dependent variants of the same word, whereas the overlapping distributions of [t] and [z] will lead the infants to interpret *tilu* and *zilu* as different words.

In the current study, however, the focus was to test for biases on how infants generalize this learning, so we tested infants instead on words beginning with novel pairs of sounds.

Infants in the Bias condition were exposed to an alternation involving dissimilar sounds ([p ~ v] or [t ~ z]), but were tested on the similar pairs of sounds ([b ~ v] or [d ~ z]). Infants in the Control condition had the opposite experience: they were exposed to an alternation involving similar sounds ([b ~ v] or [d ~ z]), but tested on the dissimilar pairs of sounds ([p ~ v] or [t ~ z]). Thus, each infant heard two novel sounds during the test phase ([b, d] in the Bias condition, [p, t] in the Control condition), which were never encountered during exposure.

Within a condition, the same twelve test trials were used for all infants regardless of sub-group. Following White et al. (2008), the test words were presented without *na* or *rom*, removing the conditioning context for the alternation. Because infants could not rely on transitional probabilities at test, finding differences would suggest infants have learned that alternating forms are related at an abstract level.[1]

For each sub-group, one of the two novel test sounds ([b] or [d] in the Bias condition, [p] or [t] in the Control condition) was at the same place of articulation as the sounds taking part in the phonological alternation during exposure (Alternating trials), and the other novel sound was at the place of articulation of the contrastive sounds (Contrastive trials). If infants are biased to prefer alternations between similar sounds, infants in the Bias condition were predicted to have different looking times to the

[1] Still, as a reviewer points out, the assumption that infants treat the stimuli as "words" should be considered speculative given the nature of the task. Our conclusions do not rest on this point.