



Research Article

Plosive voicing in Afrikaans: Differential cue weighting and tonogenesis

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ARTICLE INFO

Article history:

Received 17 October 2016

Received in revised form 28 September 2017

Accepted 28 September 2017

Keywords:

Voicing

Fundamental frequency

Afrikaans

Speech perception

Production-perception relation

Cue weighting

ABSTRACT

This study documents the relation between f_0 and prevoicing in the production and perception of plosive voicing in Afrikaans. Acoustic data show that Afrikaans speakers differed in how likely they were to produce prevoicing to mark phonologically voiced plosives, but that all speakers produced large and systematic f_0 differences after phonologically voiced and voiceless plosives to convey the contrast between the voicing categories. This pattern is mirrored in these same participants' perception: although some listeners relied more than others on prevoicing as a perceptual cue, all listeners used f_0 (especially in the absence of prevoicing) to perceptually differentiate historically voiced and voiceless plosives. This variation in the speech community is shown to be generationally structured such that older speakers were more likely than younger speakers to produce prevoicing, and to rely on prevoicing perceptually. These patterns are consistent with generationally determined differential cue weighting in the speech community and with an ongoing sound change in which the original consonantal voicing contrast is being replaced by a tonal contrast on the following vowel.

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1. Introduction

The contrast between voiced and voiceless plosives is cued by multiple acoustic properties both within and across languages. Two widely recognized properties are the onset of voicing relative to release of plosive closure (voice onset time or VOT) and the fundamental frequency (f_0) of the vowel following the plosive. Although VOT is often the primary information for this contrast, post-plosive f_0 has been shown to provide reliable, even if typically less robust, information. The basic pattern is for vowels to have higher f_0 after voiceless than after voiced plosives.

This study examines the contributions of VOT and f_0 to voicing contrasts in contemporary Afrikaans. It investigates how older and younger speakers in an Afrikaans speech community produce word-initial plosives, and how they perceptually differentiate between the two plosive voicing categories. Anticipating one main outcome, we find that the VOT differences between phonologically voiced and voiceless plosives vary both within speakers and between generations, with younger speakers being especially likely to produce phonologically

voiced plosives as voiceless unaspirated.¹ We explore whether this generational difference in plosive VOT production is accompanied by age differences in vocalic f_0 production. We investigate as well whether production patterns for VOT and f_0 align with listeners' perceptual use of the two properties. The results are interpreted relative to the literature on cue weighting and sound change, especially in terms of whether the findings are more indicative of a situation of variable cue weighting or of an ongoing sound change in which the historical voicing contrast may be in the process of being replaced by a tonal contrast.

In this introductory section, we review relevant background about cue weighting, about how small f_0 perturbations due to consonantal voicing can over time be exaggerated and start functioning as independent phonemic tonal contrasts, about the history of the plosive voicing contrast in Afrikaans, and

¹ Throughout this paper, we will refer to the historically voiced plosives of Afrikaans (that are often realized as voiceless in terms of VOT) as either "historically voiced" or "phonologically voiced". These designations are used for the sake of convenience and are not intended to indicate that Afrikaans has lost plosive voicing or that the phonological contrast between the plosive categories is necessarily a voicing contrast for all speakers. As we document below, many, especially older, speakers regularly produce these plosives with prevoicing so that plosive voicing is not only a historical property of Afrikaans. On the other hand, many, especially younger, speakers rarely produce historically voiced plosives with prevoicing, so it is unclear whether these plosives still have the phonological representation of "voiced" for these speakers.

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about the relation between individuals and the speech community to which they belong in terms of variation and sound change.

1.1. Cue weighting

The multiple acoustic properties associated with a given speech contrast have often been shown to enter into a trading relation such that stronger information for one property can offset weaker information for another, both in production and perception. Of particular interest here is the relative weighting of VOT and f_0 as information for voicing contrasts. These weights have been shown to vary for speakers of different languages (e.g., Llanos, Dmitrieva, Shultz, & Francis, 2013), first and second language speakers (e.g., Schertz, Cho, Lotto, & Warner, 2015), and speakers of the same first language (e.g., Massaro & Cohen, 1976, 1977; Shultz, Francis, & Llanos, 2012). In this study, we ask whether VOT and f_0 weights differ for older and younger speakers within a speech community. Finding a generational difference within the same speech community could be indicative of an ongoing change in the community through reweighting of the relevant acoustic properties.

Previous research has documented that, relative to phonologically voiced plosives, phonologically voiceless plosives have later onset of voicing and are followed by vowels with higher f_0 (at least for the early portion of the vowel). In English, for example, phonologically voiceless plosives are realized as aspirated. The voicelessness of these plosives is hence cued by long VOT and high f_0 . If these two properties are in a trading relation, longer VOTs for voiceless plosives should be associated with lower f_0 values, a pattern that was documented for American English by Shultz et al. (2012) and Dmitrieva, Llanos, Shultz, and Francis (2015). Similar results are also reported for perception, where studies have shown that, when post-plosive f_0 is relatively high, English listeners require shorter VOTs to identify the plosive as voiceless (Abramson & Lisker, 1985; Kong & Edwards, 2016; Llanos et al., 2013; Pearce, 2009; Whalen, Abramson, Lisker, & Mody, 1993).

In so-called true voicing languages, such as French, Spanish and Italian, the phonological voicing contrast is realized as a difference between prevoiced and voiceless unaspirated plosives. In these languages, plosive voicing is therefore indicated by both voicing lead (negative VOT) and low f_0 (with longer voicing lead and lower f_0 being more prototypically voiced). A trading relation between these two cues would be realized as a long voicing lead patterning with higher f_0 . However, the evidence for a trading relation between VOT and f_0 is less clear for prevoiced than for aspirated plosives. In a series of studies investigating the interaction between VOT and f_0 in French and Italian, Kirby and Ladd (2015, 2016) looked for correlations between the duration of voicing lead and f_0 of the following vowel, but found inconclusive evidence. Specifically, their 2015 study showed a positive correlation between voicing lead and f_0 (i.e., longer negative VOT associated with lower f_0), counter to what would be expected if these two cues were in a trading relation. Their 2016 study showed that the relation between f_0 and VOT was conditioned by the word's syntactic prominence, and differed between French and Italian.

Compared to languages that contrast unaspirated and aspirated plosives (such as English), relatively little information is

available about the perceptual interaction between f_0 and VOT in true voicing languages (such as Spanish). Llanos et al. (2013), however, investigated Spanish- and English-speaking listeners' categorization of stimuli that co-varied VOT and vocalic f_0 . They found evidence of cue trading for both groups of listeners—but only when VOT was in the positive range (i.e., similar to the results mentioned above for English). No evidence for the use of f_0 was found in the negative VOT range for either group of listeners.

Like Spanish, French and Italian, Afrikaans is, at least historically, a voicing lead language. Given the inconsistent results in the literature regarding a trading relation between VOT and f_0 for this type of language, a clear prediction cannot be made for what to expect in Afrikaans. However, if cue trading were to be observed in Afrikaans production, it should be most clear in the comparison of f_0 values for the different phonetic realizations of historically voiced plosives. For those plosives that are realized as voiced (negative VOT values), speakers would not have to rely as much on low f_0 as an additional voicing cue, since prevoicing alone is an unambiguous cue for the plosive's voicing status. Devoiced plosives (0 ms or greater VOT values), though, lack the VOT information that signals their contrast with voiceless plosives, making a lower f_0 more important. If there is a trading relation for speakers of Afrikaans, lower f_0 values should therefore be found after voiceless than voiced realizations of historically voiced plosives.

In terms of perception, a prediction that would be in keeping with the results for Spanish reported by Llanos et al. is that Afrikaans-speaking listeners would ignore f_0 in plosives that are realized with prevoicing. However, unlike the phonologically voiced plosives of Spanish, which are consistently realized as voiced, Afrikaans voiced plosives are frequently devoiced. Given this production difference, it is possible that VOT and f_0 may also perceptually pattern differently in these two languages.

1.2. From post-consonantal f_0 perturbations to tones

The correlation between consonant voicing and f_0 of neighboring vowels was noted in the early acoustics literature (Haggard, Ambler, & Callow, 1970; House & Fairbanks, 1953; Lehiste & Peterson, 1961), and has been investigated in detail in many subsequent studies. That f_0 is higher following phonologically voiceless consonants and lower following phonologically voiced consonants likely holds for all languages with voicing contrasts, although these consonantly induced f_0 perturbations are generally small, and in particular are smaller than the f_0 differences typically reported for contrasting tones. Table 1 gives a sample of the values that have been reported in the literature. Because some of these values represent the average f_0 across the entire vowel, some the f_0 at vowel onset, and others the f_0 peak (as indicated in the second column of the table), comparisons should be done with care. As is clear from the table, however, even at vowel onset, where the influence of the neighboring consonant is likely to be largest, the f_0 differences between post-voiced and post-voiceless vowels are relatively small, ranging from 8 to 16 Hz. This difference is, in particular, smaller than the typical difference observed between tones in languages with phonemic tonal contrasts. In Yoruba, for instance, the mean f_0 difference

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