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Prosodic strengthening of German fricatives in duration and assimilatory devoicing

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Abstract

This study addressed prosodic effects on the duration of and amount of glottal vibration in German word-initial fricatives /f, v, z/ in assimilatory and non-assimilatory devoicing contexts. Fricatives following /ə/ (non-assimilation context) were longer and were produced with less glottal vibration after higher prosodic boundaries, reflecting domain-initial prosodic strengthening. After /t/ (assimilation context), lenis fricatives (/v, z/) were produced with less glottal vibration than after /ə/, due to assimilatory devoicing. This devoicing was especially strong across lower prosodic boundaries, showing the influence of prosodic structure on sandhi processes. Reduction in glottal vibration made lenis fricatives more fortis-like (/f, s/). Importantly, fricative duration, another major cue to the fortis-lenis distinction, was affected by initial lengthening, but not by assimilation. Hence, at smaller boundaries, fricatives were more devoiced (more fortis-like), but also shorter (more lenis-like). As a consequence, the fortis and lenis fricatives remained acoustically distinct in all prosodic and segmental contexts. Overall, /z/ was devoiced to a greater extent than /v/. Since /z/ does not have a fortis counterpart in word-initial position, these findings suggest that phonotactic restrictions constrain phonetic processes. The present study illuminates a complex interaction of prosody, sandhi processes, and phonotactics, yielding systematic phonetic cues to prosodic structure and phonological distinctions.

1. Introduction

The fine phonetic details of segment realizations are determined both by prosodic structure (e.g., Byrd, Kaun, Narayanan, & Saltzman, 2000; Cho, 2004; Fougeron, 2001; Keating, Cho, Fougeron, & Hsu, 2003; Pierrehumbert & Talkin, 1992; Shattuck-Hufnagel & Turk, 1996; Wightman, Shattuck-Hufnagel, Ostendorf, & Price, 1992) and by sandhi processes such as coarticulation and assimilation (cf. Kühnert & Nolan, 1999). The variable phonetic patterns due to prosodic structure are often described under the rubric of 'prosodic strengthening' which can be defined as "temporal and/or spatial expansion of articulation due to accent and/or prosodic boundary" (Cho, 2005). Importantly, sandhi processes are themselves also constrained by prosodic structure: They are typically more robust and frequent across lower than higher prosodic boundaries

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(cf. Nespor & Vogel, 1986; Selkirk, 1986). In the present study, we examine the combined effects of prosodic strengthening and a sandhi process in a context where the two factors are expected to affect the acoustic realization of fricatives in opposite directions.

More specifically, this study examines prosodic strengthening in combination with assimilatory devoicing in German fricatives. Both processes may affect acoustic cues to the fortis-lenis distinction in fricatives (Fischer-Jørgensen, 1963; Jessen, 1998 for German; Cole & Cooper, 1975; Pirello, Blumstein, & Kurowski, 1997 for English). Initial strengthening may make fricatives more fortis-like in higher prosodic domains, but assimilatory devoicing may make them more fortis-like in lower prosodic domains. The combined effect of the two prosodically conditioned processes may depend on how exactly they influence the different acoustic cues to the fortis-lenis distinction. Furthermore, the combined effect may depend on language-specific lexical/phonotactic constraints (e.g., the /s/-/z/ contrast in German does not occur in word-initial position whereas the /f/-/v/ contrast does). We investigated the fine-grained acoustic realization of German fricatives in three different prosodic conditions and in assimilation and non-assimilation contexts.

1.1. Phonetic and phonological correlates of prosodic structure

Many studies in various languages, including Dutch, English, French, Korean, and Taiwanese, have shown that prosodic structure affects the fine acoustic details of segment realizations. A well-known acoustic correlate of prosodic structure is 'Final Lengthening': Domain-final syllables are longer than medial ones (Wightman et al., 1992). Another correlate is 'Initial Strengthening': Consonants show more linguo-palatal contact (Fougeron & Keating, 1997; Cho & Keating, 2001; Fougeron, 2001), stops show longer closures and longer Voice Onset Time (Pierrehumbert & Talkin, 1992; Jun, 1998; Keating et al., 2003), and vowels are more often glottalized (Dilley, Shattuck-Hufnagel, & Ostendorf, 1996) and show greater resistance to vowel-to-vowel coarticulation (Cho, 2004) in domain-initial than in domain-medial position. Both Final Lengthening and Initial Strengthening are assumed to be generally cumulative in the vertical dimension of the prosodic hierarchy, that is, the higher the prosodic domain, the stronger the effects.

Initial Strengthening suggests that prosodic structure might also influence sandhi processes, such as assimilation: Sandhi effects on initial segments may be weaker at higher prosodic boundaries (cf. Cho, 2004 for similar coarticulatory effects). This hypothesis is in accordance with evidence collected within the framework of Prosodic Phonology, where prosodic constituents are explicitly defined as application domains of phonological processes (Nespor & Vogel, 1986; Selkirk, 1986; Jun, 1998). An example is French *liaison*, that is, the realization of an underlying word-final consonant before a following vowel (see /t/ in 1a), whereas the consonant does not surface in the citation form of the word (1b) or before a following consonant (1c). *Liaison* only applies between words that belong to the same phonological phrase, but not across phrase boundaries (example 1d, taken from Nespor & Vogel, 1986, p. 179):

(a) vocalic context: *les visiteurs sont* [sɔ̃t] *arrivés* 'the visitors have arrived',
(b) citation form: *sont* [sɔ̃] '(they) are',
(c) consonantal context: *les visiteurs sont* [sɔ̃] *partis* 'the visitors have left',
(d) phrase boundary: *Le garç-on les aidait* [ɛdɛ] // *activement*. 'The boy helped them actively'.

1.2. Assimilatory devoicing of German fricatives

In the present study, we addressed the role of prosodic structure in the realization of word-initial fricatives in German, and explicitly investigated the possible interaction of domain-initial prosodic strengthening and assimilatory devoicing. We focused on /v, z, f/ in word-initial position. The fricatives /v/ and /z/ are the only German lenis fricatives which occur word-initially in the native vocabulary. Importantly for our research, /z/ has been described to be realized as [s] after voiceless obstruents (Kohler, 1990, p. 79; Kohler, 1995, p. 160). For example, *sich* 'her-/himself' is pronounced as [zɪç] in isolation, but the sequence *hat sich* 'has her-/himself' as [hatsɪç]. However, the assimilation is sometimes incomplete (Jessen, 1998), that is, it is gradient rather than categorical. /v/ also is assimilated after voiceless obstruents, but always remains distinguishable from /f/ (Kohler, 1995).