The Phonological Implications of Speaking Rate Effects in German Stops

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A growing body of research documents asymmetric effects of speaking rate on the phonetic cues that realize laryngeal contrasts in a variety of languages, providing an intriguing new source of evidence for the phonological feature specifications underlying these contrasts.

For example, Kessinger & Blumstein (1997) tested the effect of speaking rate on Voice Onset Time in word-initial stops in French, English, and Thai. French contrasts prevoiced and short-lag VOT in stops, while English has a different two-way stop contrast: short-lag vs. long-lag VOT. Thai contrasts prevoiced, short-lag, and long-lag stops. K&B found an asymmetric effect of speaking rate: as rate *decreased*, long-lag VOTs on stops *increased* in English and Thai and the amount of prevoicing *increased* in Thai and French, but *there was little or no change in short-lag VOT* in any case. Similar asymmetries have been found for Icelandic (Pind 1995), Spanish (Magloire & Green 1999), and Russian (Kulikov 2012).

Beckman et al. (2011) argue that these findings make sense if, as many phonologists assume, the contrast in Thai is one of privative [spread glottis] ([sg]), [voice], and [ø], whereas the two-way contrasts in French and English are [voice]/[ø] and [sg]/[ø], respectively. In K&B's data, the phonetic cue(s) for *only the active/marked feature(s) in a phonological contrast* are selectively increased at slower speaking rates. Thus, long-lag VOT, a cue for the specified feature [sg], increased at slower rates in K&B's English and Thai subjects; prevoicing, a cue for the specified feature [voice], increased at slower rates in French and Thai. Short-lag VOTs didn't vary according to rate for any of K&B's subjects, supporting the notion that voiceless unaspirated stops are the unmarked phonological category.

Beckman et al. provide further evidence for their interpretation of the data with a rate effect study of Swedish, where the stop contrast is "overspecified" with both [voice] vs. [sg] (Helgason & Ringen 2008). Beckman et al.'s subjects increased prevoicing *and* long-lag VOT in word-initial stops at slower speech rates, as expected—*phonetic cues for both of the phonologically marked categories changed as a function of speaking rate.*

Following up on this hypothesis, Kulikov (2012) applied the speaking rate paradigm to an investigation of VOT in Russian, a language in which the contrast is unambiguously [voice] vs. [ø]. Kulikov examined the effect of rate on word-initial VOT, finding that voicing lead in word-initial stops increased at slower speech rates, but that short-lag VOT was unaffected. Kulikov also tested the effects of speech rate on stops in connected speech, examining both word-initial and word-medial stops in intervocalic contexts. Kulikov found that, as predicted by Beckman et al., *the phonetic cues associated with medial [voice] stops, but not unspecified stops, were also increased in slow speech*—the ratio of voicing during closure was higher in medial [voice] stops produced in slow speech, but the ratio of closure voicing in unspecified stops, and the VOT duration in these stops, was unaffected by rate differences.

In this paper, we examine speaking rate effects on VOT in both initial and intervocalic stops in the speech of native speakers of (northern) German. The contrast in (northern) German stops is typically realized as one of short-lag (orthographic *b, d, g*) vs. long-lag (orthographic *p, t,* k) VOT in initial position, with some (passive) voicing of short-lag stops in intervocalic position (Jessen 1998). If the German phonological contrast is [sg]/[ø] (Iverson & Salmons 1995, Jessen & Ringen 2002) rather than [voice]/[ø] (Rubach 1990, Hall 1992, Lombardi 1999), the prediction is clear: VOTs should increase in long-lag stops in slower speech, but VOTs in short-lag stops shouldn't vary as a function of speaking rate. Further, the closure voicing of short-lag stops in medial position, which is argued to be a passive phonetic effect (Jessen & Ringen 2002), rather than an active phonological effect, should not vary as a function of speaking rate.

We recorded 8 native speakers of German (6 fem., 2 male), producing words with initial or medial stops embedded in a carrier sentence at both a normal (slow) and speeded (fast) speaking rate. For initial stops, VOT was measured; for medial stops, VOT, closure duration, voicing duration, and voicing ratio (voicing duration/closure duration) were measured.

Preliminary results for 4 speakers confirm that, as predicted by the [sg] analysis of German, VOTs are significantly longer at the slower speaking rate for the long-lag series of stops in initial position (M_{slow} = 64.59ms, M_{fast} = 45.67ms, $F(1,8)=286.094$, $p<.001$), while VOTs for the short-lag initial stops are not significantly different at the two rates (M_{slow} = 9.55ms, M_{fast} = 14.76ms, $F(1,8)=2.362$, $p=.163$). (Data for the remaining four speakers are currently being analyzed.)

In medial position, our German results are also consistent with the [spread glottis]/[ø] hypothesis (and quite different from Kulikov's findings for the Russian [voice]/[ø] contrast). VOTs for the German long-lag series were longer at the slower speaking rate (M_{slow} = 37.67ms, M_{fast} = 29.62ms, $F(1,8)=26.040$, $p=.001$), but VOTs for the short-lag series of stops were not significantly different (M_{slow} = 13.73ms, M_{fast} = 12.50ms, $F(1,8)=4.679$, $p=.062$). Furthermore, the voicing ratio for the long-lag *p,t,k* also differed significantly as a function of speaking rate (M_{slow} = .315, M_{fast} = .361, $F(1,8)=7.306$, $p=.027$), while the voicing ratio for short-lag *b,d,g* did not. (M_{slow} = .949, M_{fast} = .879, $F(1,8)=2.849$, $p=.130$).

These results add to the growing database of speaking rate effects on the phonetic cues associated with laryngeal contrasts in the world's languages, establishing that in German, as in English, Icelandic and Swedish, the VOT of initial long-lag stops is asymmetrically affected by changes in speaking rate. More importantly, the medial stop data, which have not been examined in any previous rate effect studies of aspirating languages, show an asymmetric effect similar to that of word-initial stops: cues in the long-lag, but not the short-lag, series vary as a function of speaking rate. These findings provide further empirical support for the [sg]/[ø] phonological analysis of the German laryngeal contrast.

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