PHONETIC vs. PHONOLOGICAL LENGTHENING IN AFFRICATES

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ABSTRACT

Affricate consonants consist of two portions: stop closure and frication. Can these portions play different roles in phonetic and phonological processes? In this study, I address the question by probing the behavior of Hungarian affricates under lengthening. I measure the duration changes that affricates undergo in two types of lengthening processes: first, a phonetic process of final lengthening and second, a phonological process of gemination. I show that these two processes alter the internal structure of affricates in very different ways. The results suggest that the difference between phonetic and phonological processes is in fact deeper than a mere difference between "gradient" and "categorical" effects.

Keywords: affricates, geminates, Hungarian

1. INTRODUCTION

Consonants can lengthen as the result of their position in a syllable, word or phrase. This finding has been demonstrated for a number of different languages [1]. For example, consonants at the beginning or end of a word tend to be longer than those which are medial. Such processes are typically considered to be gradient and phonetic, because they do not alter the phonemic status of the consonant.

Consonants can also lengthen as the result of morpho-phonological conditioning. For example, a suffix that triggers gemination will lengthen the final consonant of the root to which it attaches. Such a process is typically considered categorical and phonological, because the phonemic status of the consonant changes from singleton to geminate.

Both lengthening processes affect the edges of roots or words, which means that we can study them in tandem. Consider the Hungarian root *vas* [vaʃ] 'iron', which may occur in isolation or with suffixes. To get an idea of how phonetic lengthening operates, we can compare the duration of [ʃ] when it is word-final (when the root is bare) with its duration when it is word-medial (when the root is suffixed, as in *vason* [vaʃon] 'iron-SUPERESSIVE').

We can also compare the duration of [ʃ] when it is singleton versus when it is geminate. In Hungarian, the instrumental case suffix -*al* triggers gemination when it attaches to a noun root: *baj* 'trouble', *bajjal* 'trouble-INSTR'; *vas* 'iron', *vassal* 'iron-INSTR', etc. To get an idea of how phonological lengthening operates, then, we can compare the duration of [ʃ] when it is singleton (with plain suffix, as in *vason* [vaʃon]) with its duration when it is geminate (with geminating suffix, as in *vassal* [vaʃ:al]).

We might reasonably expect phonetic lengthening to be smaller and more variable than phonological lengthening, which would suggest that the two processes lie along a continuum of sorts. If we introduce affricates into the picture, however, we have the potential to uncover deeper differences. This is because affricates consist of two portions, stop closure and frication. While there is disagreement as to how these portions are best represented underlyingly [2], all theories agree that the structure of affricates is more complex than that of simple segments.

The null hypothesis is that phonetic and phonological lengthening treat the complex structure of the affricate in the same manner: for example, by lengthening both portions to a certain degree. If, on the contrary, phonetic lengthening specifically targets one portion of the affricate while phonological lengthening targets another, this suggests that the former is not merely a gradient version of the latter.

To pursue this question, the present study analyzes phonetic and phonological duration changes in stops, fricatives, and affricates in Hungarian.

2. METHODS

Stimuli, from [3], were constructed using a set of monosyllabic and disyllabic Hungarian noun roots ending in one of two affricates /ts, tʃ/ or one of three simple consonants /t, s, ʃ/. The root-final consonants occurred in four different syllable types: CVC, CVNC, CV:C, and CV:NC, giving rise to a total of eight root shapes. The vowel of the final syllable was always /a/.

Table 1: Root shapes used in stimulus construction

	Monosyllable	Disyllable
(CV).CVC	/katʃ/	/pamatʃ/
(CV).CVNC	/mantʃ/	/parantʃ/
(CV).(C)V:C	/a:tʃ/	/tana:tʃ/
(CV).CV:NC	/ga:ntʃ/	/zoma:ntʃ/

Note that vowel length differences do not correlate with consonant length differences in Hungarian. Stress is always on the first syllable.

The root list was initially designed to contain 5 root-final consonant types x 8 word shapes x 2 repetitions of each shape = 80 roots. Because of gaps in the lexicon of Hungarian (for example, there is no monosyllabic noun root with the shape Ca:nʃ), the final number of roots was 63.

To construct the stimuli, each noun root was placed in three environments: bare (unsuffixed), suffixed with a plain case ending (Superessive -*on*), or suffixed with a geminating case ending (Instrumental -*al*).

Table 2: Three environments for roots

Bare	Plain suffix -*on*	Geminating suffix -*al*
/tʃat/	/tʃaton/	/tʃattal/
/vaʃ/	/vaʃon/	/vaʃʃal/
/katʃ/	/katʃon/	/kattʃal/

Each word (63 roots x 3 environments=189) was embedded in a quoted phrase within a carrier sentence *Marika azt mondta hogy "X" gyorsan,* "Marika said 'X' quickly". For bare roots, this context should trigger both phrase-final and word-final lengthening, maximizing the phonetic effect. The order of sentences was randomized, and fillers interspersed throughout. Three native speakers of Hungarian (2 female, 1 male) read each list (189 words x 3 speakers = 567 tokens total). They were instructed to pronounce the sentences in a casual manner. Recording took place using a head-mounted microphone and Marantz digital recorder.

Segmentation took place in Praat, using waveforms and spectrograms. Stops (and stop portions of affricates) began when the preceding vowel displayed no more periodicity, and ended just before the release burst. Fricatives (and fricative portions of affricates) began at the onset of aperiodic energy, and ended at the cessation of aperiodic energy. Breathy offset at the end of words was not included in segment durations.

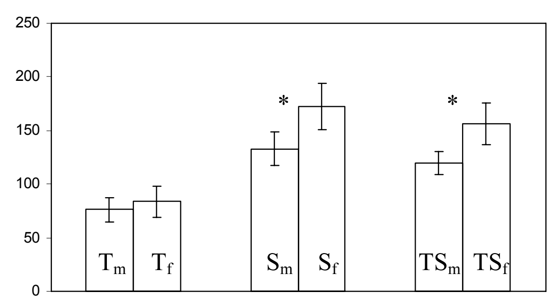
We will be concerned with two comparisons. To examine final lengthening effects, we will compare the target consonants in word-medial versus word-final environments ([ka**tʃ**on] versus [ka**tʃ**]). To examine gemination effects, we will compare the target consonants in singleton and geminate environments ([katʃon] versus [ka**ttʃ**al]).

3. RESULTS

3.1. Final lengthening

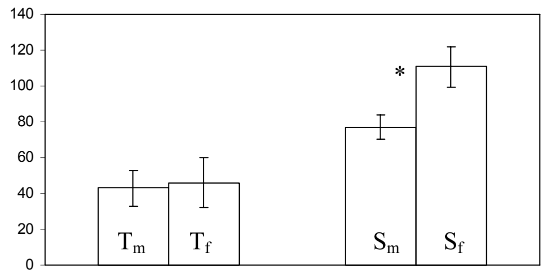
Overall, results suggest that final lengthening targets the fricative portion of an affricate. Figure 1 shows mean durations for stops, fricatives, and affricates in word medial and final positions. In this and subsequent graphs, T represents stops or stop portions of affricates, S represents fricatives or fricative portions of affricates (/s/ and /ʃ/ are pooled together), and TS represents affricates (/ts/ and /tʃ/ are pooled together). Paired t-tests ($p < 0.05$) indicate that the fricatives lengthen significantly in the word-final environment (mean increase 39.3 ms), as do the affricates (36.2 ms). Stops, however, do not.

Figure 1: Mean duration of stops (T), fricatives (S), and affricates (TS) in medial (m) and final (f) environments, in milliseconds



Looking inside the affricates, we see that the durations of the stop and fricative portions change by different amounts (Fig. 2). While the stop portion shows a small, insignificant increase in duration, the fricative portion shows a substantial, significant increase (mean 33.8 ms, $p < 0.05$).

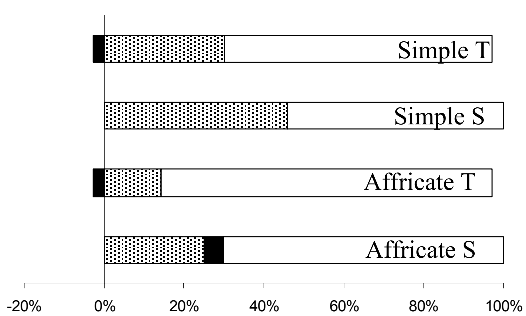
Figure 2: Within affricates: Mean duration of stop and fricative portions in medial and final environments, ms



Duration ratios paint a roughly similar picture of final lengthening for affricates. Ratios were calculated by dividing the duration of the target by the total duration of the final VC sequence in the root. Thus for *kacs* [katʃ] 'fringe', the ratio for stop portion of the affricate is [t]/[atʃ]. A value of 0.25 indicates that the [t] takes up 25% of this total duration.

Figure 3 shows duration ratios for simple segments T and S, and for the T and S portions of affricates. Shading indicates the percentage that the target occupies in word-medial position, while black indicates the relative increase (or decrease) in percentage that takes place in word-final position. Under this calculation, the fricative portion of affricates is the only item that lengthens, by a mean of 5.0%. Stop portion of affricates, as well as plain stops, actually shorten somewhat, and plain fricatives do not exhibit any change at all. This is probably due to the fact that the vowel in a VC sequence can also lengthen word-finally.

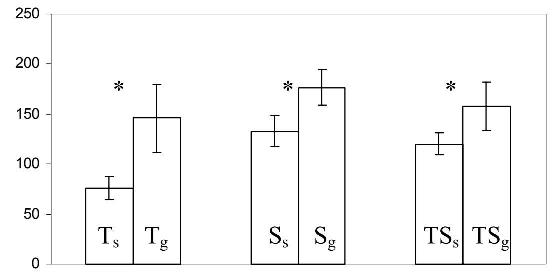
Figure 3: Target duration in medial (shaded) and final environments (shaded + black), as percent of final VC



3.2. Gemination

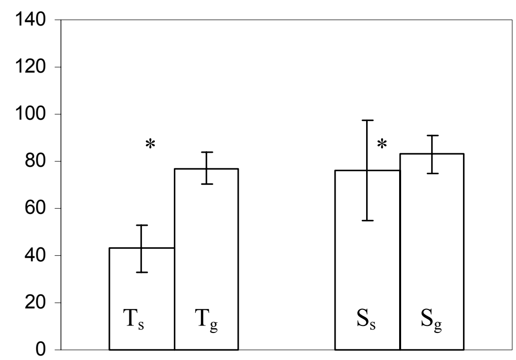
Overall, results suggest that gemination targets the stop portion of an affricate. Figure 4 shows mean durations for stops, fricatives, and affricates in the word medial singleton and geminate environments. Paired t-tests ($p < 0.05$) indicate that all three consonant types lengthen significantly (mean increase for stops: 69.9 ms; for fricatives: 43.9 ms; for affricates: 38.1 ms).

Figure 4: Mean duration of consonants in singleton (s) and geminate (g) environments, ms



Looking inside the affricates, we see that the durations of the stop and fricative portions again change by different amounts (Fig. 5), but the changes are not the same as what we saw with final lengthening. While the fricative portion shows a very small increase in duration (mean 6.1 ms, $p < 0.05$), the stop portion shows a substantial increase (mean 33.0 ms, $p < 0.05$).

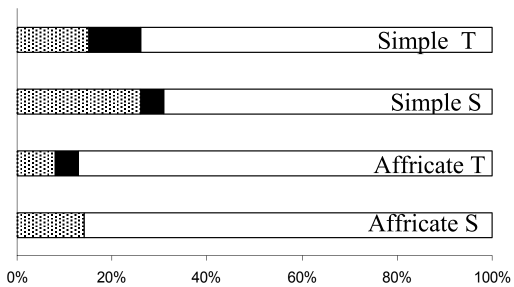
Figure 5: Within affricates: Mean duration of closure and frication in singleton and geminate environments



Duration ratios included more segments for the singleton-to-geminate comparison than for the medial-to-final comparison. Here, ratios were calculated by dividing the duration of the target by the total duration of the final disyllabic sequence in the word. Thus for a singleton environment as in *kacson* [katʃon] 'fringe-SUPERESS', the ratio for the stop portion of the affricate is [t]/[atʃon]. For a geminate environment as in *kaccsal* [kat:ʃal] 'fringe-INSTR', the ratio for stop portion of the affricate is [t]/[at:ʃal].

Figure 6 shows duration ratios for simple consonants T and S, and for the T and S portions of affricates. Both of the simple consonants lengthen significantly, as does the stop portion of affricates. The only item that does not lengthen in the geminate environment is the fricative portion of affricates, which exhibits no change.

Figure 6: Target duration in singleton (shaded) and geminate environments (shaded + black), as percent of final VCVC.



4. DISCUSSION

Different lengthening processes have very different effects on affricates. The phonetic process of word-final lengthening targets the fricative portion of an affricate, but the phonological process of gemination targets the stop portion.

The difference between phonetic and phonological lengthening is typically thought to be one of degree. This is evident, for example, in the results that I have presented for plain consonants. But the results for affricates demonstrate that the difference between phonetic and phonological lengthening is also one of type, because each process targets a different portion of the affricate.

This difference in type is remarkable because there are a number of reasons to think that phonological lengthening *should* target the fricative portion of affricates, especially when the environment for lengthening lies directly adjacent to it as in the current study. For one thing, affricates can pattern like fricatives in phonological processes. In Hungarian, for example, sibilant fricatives undergo regressive assimilation [4], such that /s-ʃ/ → [ʃʃ] and /ʃ-s/ → [ss]. Affricates containing sibilant fricatives can trigger this same process, /s-tʃ/ → [ʃtʃ], and can undergo it as well, /tʃ-s/ → [tss]. This suggests that the fricative portion of an affricate possesses the same status as a simple fricative (although see [2]). Since simple fricatives lengthen under gemination, why not fricatives in affricates?

Furthermore, studies have found that English [5] and Hungarian [6] listeners can perceive an affricate even in the absence of its closure portion, probably because affricate frication exhibits a very abrupt rise. The perceptual evidence thus seems to concur with the phonological evidence: the fricative portion possesses an independent status. So why does it not lengthen under gemination?

The current study eliminates one of the theoretically possible answers to this question. Speakers implement duration increases in fricative portions in word-final position, so the constraint on fricative lengthening cannot be an articulatory one, but must be phonological in nature.

Note that unlike their plain consonant counterparts, affricates do not exhibit different degrees of *overall* lengthening in phonetic versus phonological environments. Counting both stop and fricative portions together, an affricate lengthens by roughly equivalent amounts in the final lengthening (mean increase 36.2 ms) and gemination environments (38.1 ms). It thus appears as if there is a trade-off between degrees and types of lengthening: when phonetic and phonological processes are not distinguished by degree of lengthening, they may be distinguished by type instead. Future work with other complex segments, such as pre-nasalized stops and palatalized consonants, would reveal whether this generalization holds.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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