Phonetic Realizations of Polish Geminate Affricates

Ela Thurgood* and **Grazyna Demenko†**

*California State University, Chico
ethurgood@csuchico.edu

†Adam Mickiewicz University, Poznan
lin@main.amu.edu.pl

ABSTRACT

The study analyzes the phonetic realizations of the three Polish geminate affricates /tsts/, /tɕtɕ/ and /tʃtʃ/; the first two are morphologically derived, the third geminate is lexical. The study shows that all the phonologically geminate affricates are phonetically manifested variably: sometimes by rearticulation of the affricate, sometimes by lengthening the duration of the stop closure component [4], and, at times, even by the lengthening the duration of the fricative component.

1 INTRODUCTION

As a preliminary, it is necessary to note that the phonological term doubly articulated geminate is used to denote a geminate in which the affricate is rearticulated phonetically; the term singly articulated geminate is used to denote a situation where either the stop or the fricative component of an affricate is significantly longer in duration than that of a singleton. Phonologically, the duration of either a doubly articulated geminate or a singly articulated geminate contrasts with the duration of a singleton.

In the production of the phonologically geminate affricates /tɕtɕ/ and /dʒdʒ/ Thurgood (2001) found two patterns: They were sometimes phonetically manifested as a singly articulated geminate and sometimes as a doubly articulated sequence. Of 27 speakers, 63% showed a two-way distinction between [tɕ] as the singleton and either [tːɕ] or [tɕtɕ] as the geminate, while 37% showed a three-way phonetic distinction between [tɕ], [tːɕ], and [tɕtɕ]. The voiced geminate /dʒdʒ/ showed the reverse pattern. Only 37% of the speakers produced a singly articulated geminate [dːʒ], while 59% produced a doubly articulated [dʒdʒ] sequence (with one speaker doing something quite different). The singly articulated geminates [tːɕ] and [dːʒ] were characterized by a longer closure duration than singletons [tɕ] and [dʒ]; length was not manifested in the fricative duration.

This study goes beyond the earlier study in a number of ways. First, the earlier study was a repetition task. This study is a production task involving reading: the data it produced differ from the earlier repetition task in a number of ways. Second, we expanded the geminates studied to include all three of the Polish voiceless geminate affricates: /tʃtʃ/, /tsts/) and /tɕtɕ/. Third, in this task, we found differences between the lexical geminate /tʃtʃ/ and the derived geminates /tsts/) and /tɕtɕ/. Fourth, unlike in the repetition task, length was sometimes manifested in the fricative component.

Two additional questions emerged that are of special interest:

(1) Are the durational values of geminate affricates similar for different places of articulation?
(2) What sort of variation exists both within individual speakers and across speakers?

2 DATA AND METHODS

The contrasting singleton and geminate sets are listed in the disyllabic words in Table 1.

WORD	GLOSS
/grɛtsɨ/	'the Greeks'
/grɛtstsɨ/	'Greek' (adjective)
/lɛtɕɛ/	'summer' (locative case)
/lɛtɕtɕɛ/	'fly' (imperative)
/utʃɛ/	'teach' (first person)
/utʃtʃɛ/	'celebrate' (first person, future)

Table 1: Target words for short and long affricates

Each word occurred in two different sets of sentences. In the first set, the target words were in the carrier phrase *Powiedz* ____ *teraz* 'Say ____ now'. In this set, there were 28 sentences: six sentences with the target words and 22 sentences with non-target words. In the second set, the target words occurred in the following sentences presented in random order.

1. W lecie jest duzo warzyw. "In summer, there are a lot of vegetables."

2. Wy leccie teraz do domu. "You should hurry home now."
3. Kiedy ucze nie mysle. "When I teach, I do not think."
4. Kiedys uczcze ten pomysl szampanem. "Some day, I will celebrate this idea with champagne."
5. Byli tam Grecy i Rzymianie. "There were Greeks and Romans there."
6. Byli tam greccy zolnierze. "There were Greek soldiers there."

Nine native speakers of Polish participated in the study (6 females, 3 males). Each subject was asked to read the 34 sentences twice. The speakers were asked to read at a comfortable conversational pace and to maintain that pace throughout the recording session. A total of 104 tokens of geminate affricates (36 tokens of /tsts/, 33 tokens of /tɕtɕ/, and 35 tokens of /tʃtʃ/) were measured and analyzed.

The measurements were done using the simultaneous displays of the spectrogram and the waveform in the Macquirer program. The temporal acoustic parameters that were measured were the duration of the singleton and of the geminate, the closure duration of the stop portion of the affricate, and the duration of the following fricative, which sometimes included a short burst of the stop release (cf. Stevens 1967:217). Following Louali and Maddieson (1999:603), closure duration was defined as "the interval from the acoustic offset of the preceding vowel, marked by a sharp drop in amplitude and loss of visible formant structure, to the release burst of the stop". The end of the fricative was taken to be the end of the friction noise and the beginning of the F2 of the following vowel.

3 RESULTS

3.1 SINGLETONS

In Figure 1, the average duration for all nine speakers for each singleton affricate type is plotted against the average duration for its closure. The total average durations of the singletons /ts/ and /tɕ/ are more than twice that of just the closure duration; the total average duration of the singleton /tʃ/ is slightly less than twice the duration of its closure component. These data, consisting of a total of 83 tokens of singletons (31 tokens of /ts/ , 18 tokens of /tɕ/, 34 tokens of /tʃ/), provide a baseline for the analysis of geminate affricates.

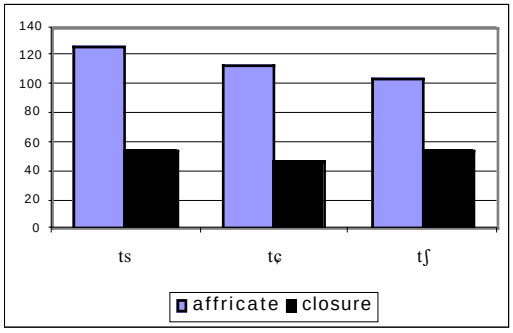

Figure 1: Average durations for singleton affricates vs. their stop closures.

3.2 GEMINATES

3.2.1 Doubly vs. singly articulated geminates. We looked at the correlation between the duration of the doubly articulated geminate and the long affricate. A paired t-test shows that for /tsts/ the difference between the duration of the doubly articulated geminate and the long affricate was not statistically significant ($t(32)=1.336$, $p>0.181413$). A paired t-test shows that for /tɕtɕ/ the difference between the duration of the doubly articulated geminate and the long affricate was statistically significant ($t(26)=-1.510$, $p< 0.06$). Similarly, a paired t-test shows that for /tʃtʃ/ the difference between the duration of the doubly articulated geminate and the long affricate was statistically significant ($t(30) = -1.555$, $p< 0.08$).

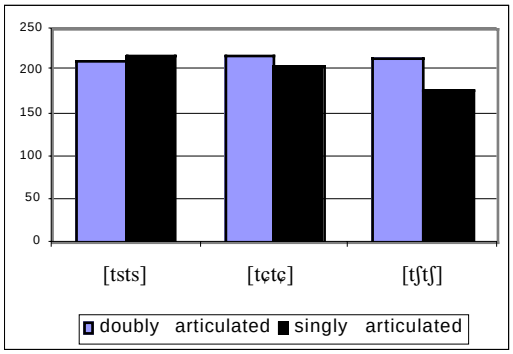

Figure 2: Mean durations of doubly and singly articulated geminates.

3.2.2 Derived vs. lexical geminates. We looked at the correlation between the geminate duration and morphological complexity. For the doubly articulated geminates whether the geminate was morphologically derived or lexical, it did not correlate with duration. But, for the singly articulated geminates, the lexically monomorphemic [tːʃ] was shorter than the morphologically complex geminates [tːs] by 48.6 ms and [tːɕ] by 36.5 ms.

3.2.3 Singly articulated geminate affricates. The ratio of singletons to singly articulated geminates was 1:1.7. The mean durations for each category of singletons and

singly articulated geminates for the 9 speakers are plotted in Figure 3. The values for geminate durations do not differentiate between the values for the two kinds of singly articulated geminates that occurred in the study: geminates articulated with a long stop closure component and geminates articulated with a long fricative component.

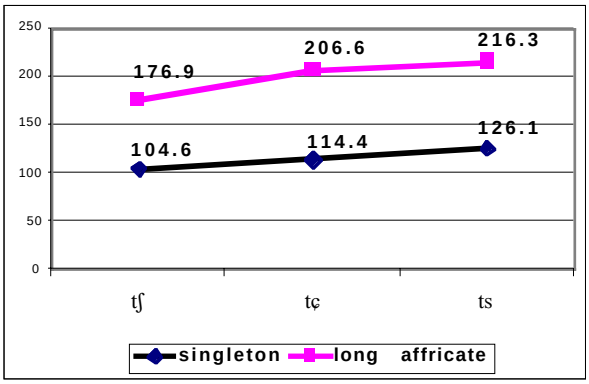

Figure 3: Mean durations for singletons vs. singly articulated geminates.

In Figure 4, the two types of singly articulated geminates are separated: the mean durations for geminates articulated with a long stop closure ([tːs], [tːɕ], [tːʃ]) are separated from the mean durations for geminates articulated with a long fricative ([tsː], [tɕː], [tʃː]). Geminates with a long closure were longer than geminates with a long fricative. [tːs] was on average 63 ms longer than[tsː]; [tːɕ] was on average 41 ms longer than [tɕː]. The difference was much smaller for [tːʃ] and [tʃː], where [tːʃ] was on average only 11 ms longer than [tʃː].

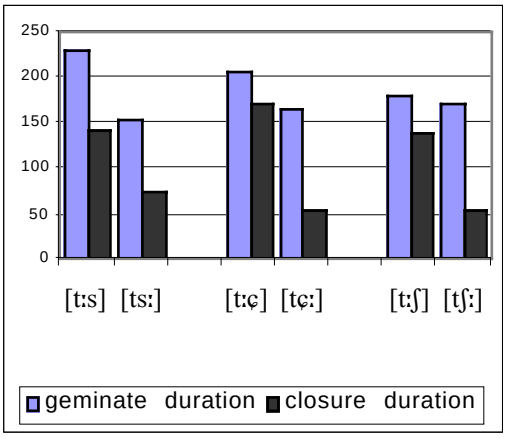

Figure 4: Mean durations for both types of long affricates

The mean closure duration for a singly articulated geminate with a long closure duration was 149.5 ms (s.d. 41.8). The mean closure duration for a singly articulated geminate with a long fricative duration was 59.1 ms (s.d. 17.4), essentially the same as the closure duration for a singleton, with the length of the fricative duration marking a particular affricate as long. The mean closure durations for each affricate category are plotted in Figure 5.

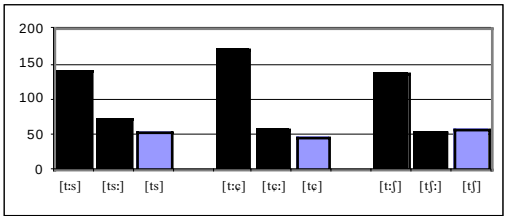

Figure 5: Mean closure durations

3.3 FREQUENCY

The 9 subjects produced 100 geminates: 68% of these geminates were doubly articulated, 32% were singly articulated. The frequencies for each geminate category are given in Figure 6.

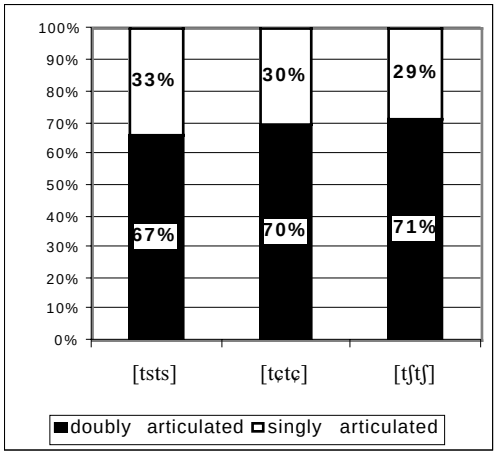

Figure 6: Frequency of geminates

Among the 32 singly articulated geminates, 18 (56%) were articulated with long closure durations and 14 (44%) were articulated with long fricative durations. Figure 7 gives frequencies for each category.

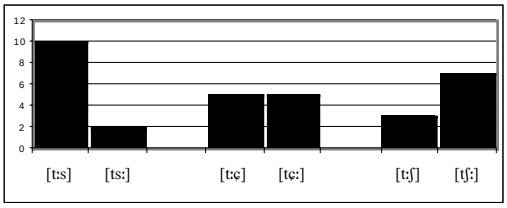

Figure 7: Frequencies of long stop closures vs. long fricatives.

3.3.1 Across speaker variation. Individual speakers varied considerably in their manifestations of geminates. As Figure 8 shows, some tended to rearticulate most of the time, while others tended to use singly articulated geminates. However, all produced both!

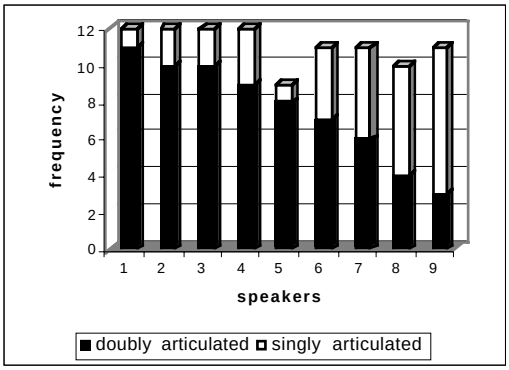

Figure 8: Cross-speaker variation.

4 DISCUSSION

Our results substantiated Thurgood's (2001) earlier finding that Polish geminate affricates are sometimes marked by double articulation and sometimes by a long component in the stop closure. However, the finding that length in the fricative could also characterize a Polish geminate is new. We note that a different task, reading instead of repetition, correlates directly with this difference in phonetic manifestation. The marking of geminate length in the fricative component of an affricate is cross-linguistically quite rare [1]; however, in these Polish data, some 44% of the singly-articulated geminates show length in the fricative component—a fairly robust number.

It is of phonetic interest that geminates with a long stop closure duration were longer than those with a long fricative duration, perhaps because extra length in a fricative is more salient than extra length in closure.

The experiment suggested that derived geminates are longer than lexical ones, but this requires more data and further substantiation.

The task affected the phonetic manifestation. In an earlier repetition task, 59.3% of the tokens were marked by length; in this reading task, only 30% were marked by length. In the earlier repetition task, none of the 27 subjects manifested instances of marking using fricative length; in this reading task, 4 out of 9 subjects displayed the use of fricative length.

ACKNOWLEDGEMENTS

We gratefully acknowledge the help of all speakers who provided the linguistic data analyzed in this paper. This research was supported in part by KBN grant (project 7T11C00921) to Grazyna Demenko.

REFERENCES

[1] J. Laver, *Principles of Phonetics*, Cambridge: Cambridge University Press, 1994.

[2] N. Louali and I. Maddieson, Phonological contrast and phonetic realization: The case of Berber stops. ICPhS 99: 603-606, 1999.

[3] P. Stevens, Spectra of fricative noise in human speech." in *Readings in Acoustic Linguistics*, I. Lehiste, Ed., pp. 202-219. Cambridge MA: MIT Press, 1966.

[4] E. Thurgood, "The phonetic realizations of phonologically geminate affricates in Polish: The Long and the Short of it." in *Speech and Language Technology*, vol. 5, pp. 9-19, 2001.