

Duration correlates of stop consonants in Cypriot Greek

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Abstract

This is a production study of stop consonant durations as a function of voice, length, stress, syllable position, speech tempo and speaker's gender in Cypriot Greek. The results indicate that all six investigated factors have a significant effect on either total duration of the stops or one of their occlusion and burst parts.

The key words are minimal syllable or lexical pairs of dissyllabic meaningful words shown in Table 1.

Table 1. Key words of the speech material.

pása	p:ása	bása	fápa	káp:a	lába
pass	quickly	bass	slap	cape	lamp
pasá	p:asá	ba'la	papá	lap:a	θabá
pasha	lord	kick	father	pap	vaguely

Introduction

In this paper, we will report a production investigation of stop consonant durations as a function of voice, length, stress, syllable position, speech tempo and speaker's gender factors in Cypriot Greek. Two main questions are addressed: (1) what is the main effect of each investigated factor? (2) is there an hierarchy among the investigated factors?

In addition, we will report an identification experiment of distinctive stop productions under the conditions of length, voice and stress.

Our general target is the accumulation of basic knowledge in syllable structure, which is expected to lead to the development of powerful linguistic models with multiple applications in language-related areas.

Five female and five male Cypriot Greek students at Linguistics Department of Athens University produced the speech material in ten repetitions at normal and fast tempo.

Duration measurements of the occlusion and burst of the stop consonants were taken with the Waveserfer and the results were subjected to statistical analysis with StatView.

Part of the key words was organized in an identification experiment, in ten repetitions, carried out by ten listeners who also took part in the production investigation.

Experimental methodology

The speech material consists of twelve key words, produced in the carrier sentence "ípa {key word} siyá" (I said {key word} quietly).

Results

In Table 2, the results of the identification experiment indicate that distinctive stop consonant productions have high identification scores (95%) with reference to all three investigated factors of length, voice and stress. The results of the production investigation are presented in Figure 1 and Figure 2.

Table 2. Intended productions of distinctive stop consonant key words in a sentence carrier by a female speaker in normal tempo and identification rates by ten listeners.

Intended		Identified					
Key words	Total	'pasa	'p:asa	'basa	pa'sa	p:a'sa	ba'la
'pasa	100	99	0	0	0	1	0
'p:asa	100	0	98	1	0	1	0
'basa	100	0	0	100	0	0	0
pa'sa	100	0	0	0	99	0	1
p:a'sa	100	0	0	0	0	100	0
ba'la	100	0	0	0	0	0	100
Total	600	99	98	101	99	102	101

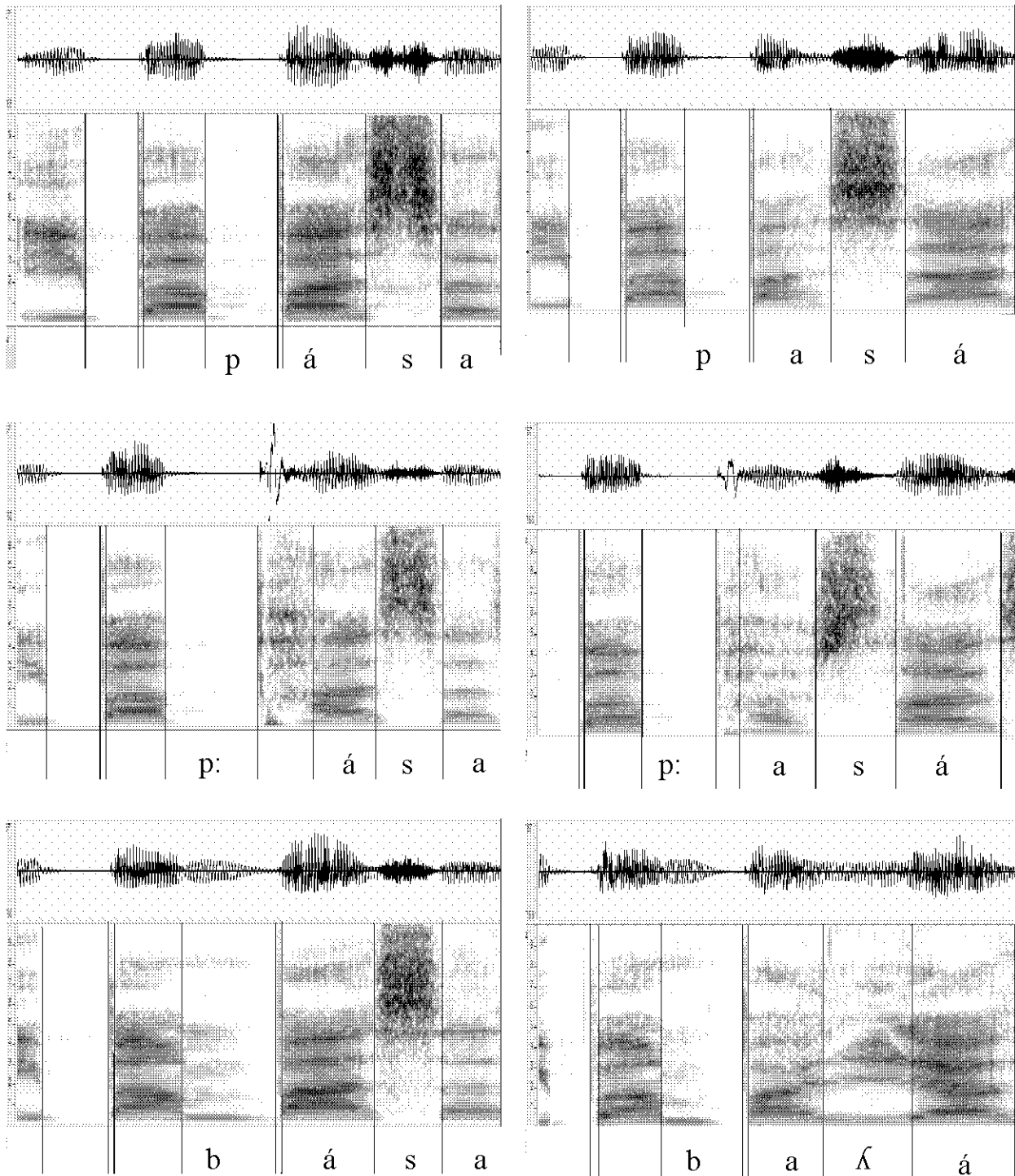


Figure 1. A female speaker's analysis of stop consonant durations as a function of length and voice (vertical disposition) and stress (horizontal disposition).

Figure 1 shows duration patterns of a female speaker's stop consonant productions as a function of length, voice and stress.

The distinctive length production (*pása* vs. *p:ása*) has a minor effect on the duration of the stop occlusion and a major effect on the duration of the stop burst, which is mainly an aspiration production effect.

The distinctive voice production (*pása* vs. *bása*) has hardly any lengthening effect on either stop occlusion or stop burst production.

The distinctive stress productions (left vs. right) has a lengthening effect on the stop occlusion and the stop burst of the long consonant production but only on the stop occlusion of the voiceless and voiced stops.

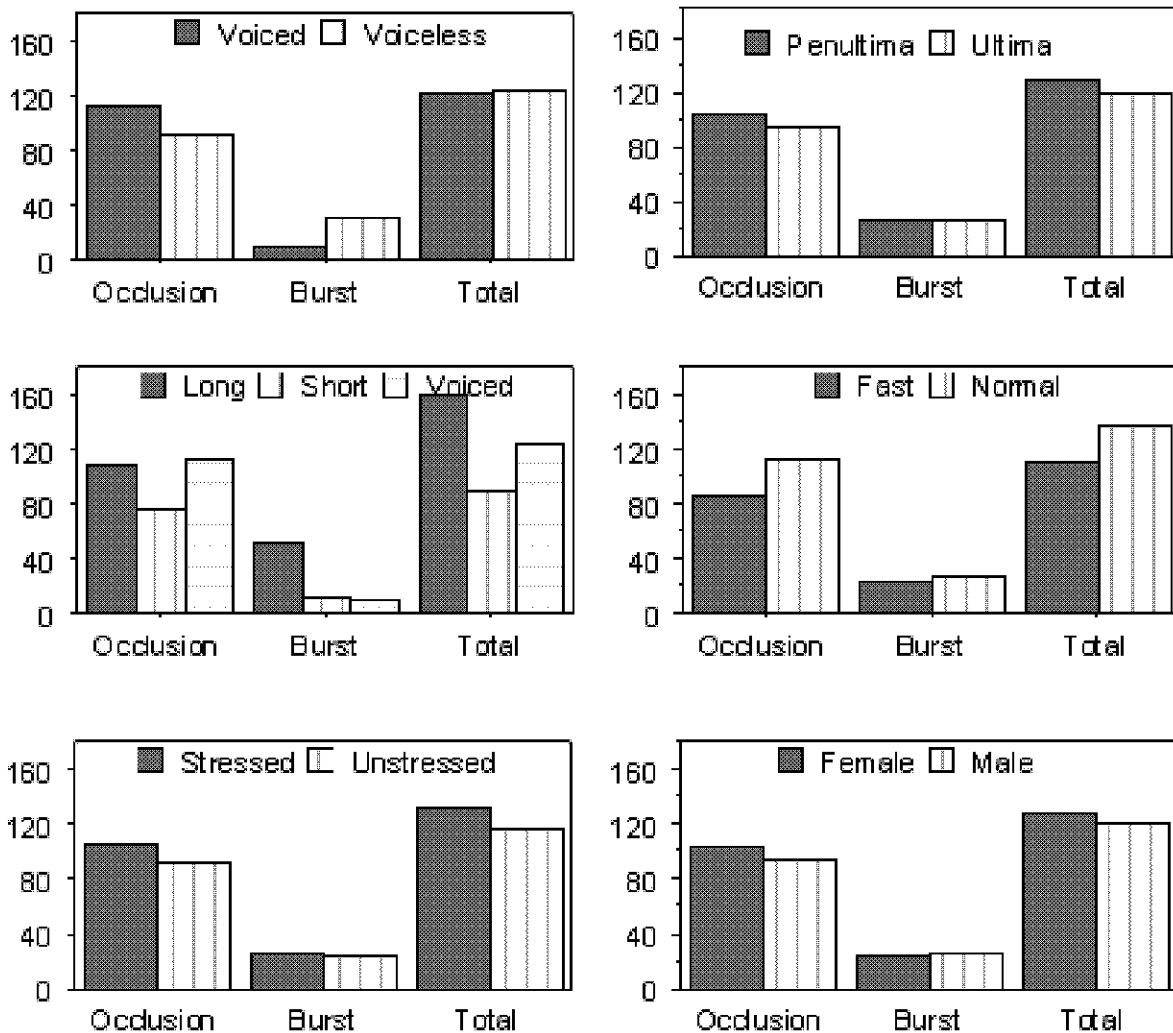


Figure 2. Stop occlusion, stop burst and total stop durations (in ms) as a function of voice, length, stress, syllable position, speech tempo and speaker's gender).

Figure 2 shows the main effects of voice, length, stress, syllable position, speech tempo and speaker's gender with reference to stop occlusion, stop burst and total stop durations.

Distinctive voice production has a significant effect on both stop occlusion and stop burst, which have a mirror image duration pattern, but not on total stop duration. The voiced stop occlusion is 21% longer than the voiceless stop occlusion (voiced=112, voiceless=92; $f=51$, $p<0.0001$); The voiceless stop burst, on the other hand, is 320% longer than the voiced stop burst (voiced=10, voiceless=32; $f=129$, $p<0.0001$) and the total voiced and voiceless stop durations are fairly the same (voiced=122, voiceless=124).

Distinctive length production has a highly significant effect on both stop occlusion and stop burst and, consequently, the total stop duration. The long stops are totally 78% longer

than the short stops and 30% longer than the voiced ones (long=159, short=89, voiced=122; $f=228$, $p<0.0001$). The long stop occlusion has fairly the same duration with the voiced stop occlusion but 42% more than the short stop occlusion (long=108, short=76, voiced=112; $f=93$, $p<0.0001$). The long stop burst is 390% longer than the short stop burst and 510% longer than the voiced stop burst (long=51, short=13, voiced=10; $f=561$, $p<0.0001$).

Distinctive stress production has a significant effect on both stop occlusion and total stop duration but not on stop burst. The stressed stops are 13% longer than the unstressed ones (stressed=131, unstressed=115; $f=18$, $p<0.001$) and this difference is 15% with reference to stop occlusion (stressed=106, unstressed=92, $p<0.0001$).

Syllable position production has a significant effect on both total stop and stop

occlusion but not on stop burst durations. The penultimate stops are 6% longer than the ultimate stops (penultimate=127, ultimate=119; $f=5.2$, $p<0.02$) and the penultimate stop occlusion is 8% longer than the ultimate one (penultimate=103, ultimate=94, $f=9.9$, $p<0.001$).

Speech tempo production has a significant effect on total stop and stop occlusion durations. The normal tempo stops are 25% longer than the fast tempo ones (normal=137, fast=109; $f=63$, $p<0.0001$); the normal tempo stop occlusion is 27% longer than the fast tempo one (normal=111, fast=87, $f=95$, $p<0.0001$); the normal tempo stop burst is 17% longer than the fast tempo one (normal=27, fast=23, $f=3$, NS).

Speaker's gender production has a significant effect on both total stop and stop occlusion durations but not on stop burst. The female stop production is 6% longer than the male stop production (female=127, male=119; $f=4.2$, $p<0.03$) and the female stop occlusion is 9% longer than the male stop occlusion (female=103, male=94; $f=11$, $p<0.001$).

To summarise the results of the production experiment, Table 3 shows the effects of each investigated factor on stop occlusion, stop burst and total stop durations in percentages.

Table 3. Percentage effects of each investigated factor on consonant stop durations.

Factors	Occlusion	Burst	Total
Voice	21%	320%	21%
Length	42%	390%	78%
Stress	15%	NS	13%
Syllable	9%	NS	6%
Tempo	27%	NS	25%
Gender	9%	NS	6%

In general, distinctive length production has a major effect on stop consonant durations, followed by speech tempo, voice and stress whereas the effects of syllable position and speaker's gender are minor. The duration of the stop burst, on the other hand, is fairly constant except for voice and length factors where aspiration production makes the difference.

Discussion and conclusions

The results of the present study indicate that stop consonants in Cypriot Greek, as most probably in all languages, are distinctive linguistic categories with fairly invariant

acoustic and perceptual correlates as both identification and production experiments have indicated.

With reference to the investigated factors we will confine our discussion to voice, length and stress productions, which are main distinctive categories in the phonetic system of Cypriot Greek.

The distinctive voice production has both stop occlusion and stop burst duration correlates. Furthermore, and equally important, the stop occlusion of the voiced and voiceless stops is fairly voiced and voiceless respectively. Duration variation of the stop occlusion as an acoustic correlate of voice distinctions has also been reported for standard Greek (Botinis, Fourakis and Prinou 2000).

The distinctive length production, like voice production, has both stop occlusion and stop burst duration correlates. It should be noted that the stop occlusion duration of the long and voiced stops is fairly the same but substantially bigger than the duration of the short stops. Thus, stop consonant length distinction in Cypriot Greek is mainly realised with a lengthening of stop occlusion, in combination with a lengthening of stop burst, which is an aspiration production speech event.

The distinctive stress production has mainly stop occlusion duration correlates. Thus, Cypriot Greek, like standard Greek, in addition to vowels, stress production has a lengthening effect on stop consonants (Botinis, Bannert, Fourakis and Pagoni-Tetlow 2002).

Concerning segmental taxonomy, Cypriot Greek seems to have a 2x2 stop consonant system of voice and length, i.e. voiced vs. voiceless and short vs. long. There is, however, substantial acoustic evidence that the latter distinction may instead be classified as an aspiration one. Variation of the stop occlusion duration as a function of length production, however, and most importantly, the length distinction across all major consonant classes in Cypriot Greek support the former approach.

References

- Botinis A., Fourakis M. and Prinou I. (2000) Acoustic structure of the Greek stop consonants. *Glossologia* 11-12, 167-199.
- Botinis A., Bannert R., Fourakis M. and Pagoni-Tetlow S (2002). Crosslinguistic segmental durations and prosodic typology. *International Conference of Speech Prosody* (Aix-en-Provence, France), 183-186.