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COMPARING THE PHONETICS OF SINGLE AND GEMINATE CONSONANTS IN CYPRIOT AND STANDARD GREEK

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Περίληψη
Η παρούσα εργασία συγκρίνει τη χρονοργάνωση (*timing*) των μονών και διπλών συμφώνων της κυπριακής με αυτή των αντίστοιχων μονών της ελληνικής, υπό την επίδραση αλλαγών στην ταχύτητα ομιλίας. Η εργασία βασίζεται σε δεδομένα από τέσσερις ομιλητές κάθε ποικιλίας, τα οποία αναλύθηκαν φωνητικά. Τα αποτελέσματα δείχνουν ότι οι φθόγγοι και των δύο ποικιλιών συντομεύουν όταν η ταχύτητα ομιλίας αυξάνει. Οι αλλαγές αυτές φαίνεται να επηρεάζουν με παρόμοιο τρόπο τόσο τους απλούς όσο και τους διπλούς φθόγγους, εκτός των περιπτώσεων εκείνων που αρθρωτικά δεν επιτρέπουν αλλαγές στη διάρκεια του φθόγγου (όπως είναι η δασύτητα των απλών συμφώνων). Επιπλέον η χρονοργάνωση της ελληνικής δεν φαίνεται να δείχνει μεγαλύτερη διακύμανση, παρά το γεγονός ότι στα ελληνικά η διάρκεια δεν έχει αντιθετική λειτουργία και συνεπώς αλλαγές στη διάρκεια δεν θα προκαλούσαν σύγχυση. Τα αποτελέσματα αυτά ερμηνεύονται με βάση τη φωνητική θεωρία και τις υπάρχουσες προβλέψεις για τη χρονοργάνωση.

1. INTRODUCTION

In the literature (e.g. Manuel, 1990), it has been suggested that the presence of a phonological contrast in a given language results in less contextual variability along the phonetic parameter that is used contrastively, in order that the linguistic contrast be maintained in all circumstances. As changes of speaking rate constitute in effect a change of context, it follows that the effects of rate on the timing of segments will partly depend on the presence of a durational contrast; i.e. less durational variability is expected in a language with a length contrast in a given set of phones, than in a language that does not have this contrast.

Arvaniti (1999) examined Standard Greek (SG) and Cypriot (CYG) single and geminate sonorants, /m/, /n/, /l/, /r/, elicited at normal and fast speaking rate, and found that variability does not depend so much on the presence of a *phonological* contrast, but on *phonetic* articulatory constraints. Specifically, she showed that both SG and CYG sonorants were affected by changes of speaking rate in a similar manner. SG sonorants, for which differences in duration are not contrastive, did not show greater variability than the CYG sonorants, which are distinguished into singleton and geminates. On the other hand, the data also showed that the SG segments were intermediate in duration between CYG singletons and geminates. This was in turn interpreted as an indication that a language may choose canonical values for its segments on the basis of existing contrasts; that is, CYG singletons are shorter than SG ones, because CYG needs to distinguish two categories of sonorants on the basis of length, and does so by making the singletons quite short.

The aim of the present study was to replicate the results of Arvaniti (1999) and also to extent the results to stops and fricatives; the stops in particular have tight articulatory constrains imposed on them, and for this reason have been the object of several empirical studies. For instance, Kessinger & Blumstein (1997) have investigated the effects of speaking rate on VOT and have shown that the short-lag VOT of unaspirated stops in French and Thai is not affected by speaking rate, while the long-lag VOT of Thai and English aspirated stops is; similarly Fourakis (1986) has shown that the short-lag VOT of Greek stops is stable under changes of stress.

2. METHOD

2.1 *Materials*

For CYG, the materials included minimal (or near minimal) pairs of disyllabic words stressed on their first or second syllable and with a single or geminate intervocalic consonant. The target (intervocalic) consonants were /p/, /t/, /k/, /s/, /m/, /n/, /l/, /r/. The complete set of test-words is presented in Table 1 (for details, see Tserdanelis & Arvaniti, this volume). For SG, the same materials were used, but involving only words with single intervocalic consonants (see Table 1). The test-words were embedded in the carrier phrase ['ipendu ___ ksafni'ka'tʃefien] "[S/he] told-him ___ suddenly and left" for CYG, and [tu'ipe___ ksanfi'ka'cefiʝe] '[S/he] to-him-said ___ suddenly and left' for SG.

Table 1: The test-words and their glosses. For the CYG materials all the test-words were used; for the SG materials only the underlined test-words were used. The glosses are the same in both varieties, except of the item [kɐ'ni].

	Penultimate stress				Final stress			
	Singleton		**Geminate**		**Singleton**		**Geminate**	
Target Phone	**Test word**	**Gloss**	**Test word**	**Gloss**	**Test word**	**Gloss**	**Test word**	**Gloss**
/p/	'pɐpɐ	'pope'	'mɐp:ɐ	'ball'	pɐ'pɐ	'daddy'	lɐ'p:ɐ	'boiled rice'
/t/	'kotɐ	'hen'	'kot:ɐ	'knock' *imp.*	po'tɐ	'drinks'	ko't:ɐ	's/he knocks'
/k/	'fɐkɐ	'mouse trap'	'fɐk:ɐ	'hit' *imp.*	kɐ'kɐ	'bad' *neut. pl.*	fɐ'k:ɐ	's/he hits'
/s/	'pisi	'persuade' *subj.*	'pis:i	'stingy' *acc.*	mi'si	'half' *fem.*	ki's:i	'ivy' *pl.*
/m/	'sɐmu	'Samos' *gen.*	'ɐm:u	'sand' *gen.*	pɐ'mu	'rest' *gen.*	mɐ'm:u	'midwife'
/n/	'kɐni	'it-does'	'kɐn:i	'gun barrel'	kɐ'ni	'enough' 'shin'SG	kɐ'n:in	'shin'
/l/	'milɐ	'apples'	'mil:ɐ	'fat' *n.*	mi'lɐ	's/he speaks'	pi'l:ɐ	surname
/r/	'vaɾɐ	'beat' *imp.*	'mbɐr:ɐ	'rod'	vɐ'ɾɐ	's/he beats'	fɐ'r:ɐ	'pasture'

2.2 *Speakers*

The CYG materials were read by four native speakers of CYG (see Tserdanelis & Arvaniti, this volume). The SG materials were read by four native speakers of SG, two males (CN, TK) and two females (AM, AS). They were all from Athens and at the time of the recording they were students at the University of Cambridge. All speakers were recorded in the unechoic chamber of the Cambridge University Phonetics Laboratory, except SP and DF who were recorded in a sound-treated booth in a Nicosia television station. Both sets of speakers read seven repetitions of the test-sentences, in random order, from cards typed following the spelling conventions of each variety, and interspersed with fillers. The materials were recorded on a DAT-corder and were redigitized and analyzed using Waves$^+$ on a Solaris UNIX workstation.

2.3 *Measurements*

Two measurements are reported here: the duration of the test-word and the duration of the test-consonant (for further details see Tserdanelis & Arvaniti, this volume). The durational data were analyzed by means of two-way analyses of variance in which the independent variables were RATE (normal/fast) and CONSONANT-TYPE (C-TYPE for short: SG/CYG-singleton/CYG-geminate). The data were not analyzed separately for each speaker, since what was of interest was the effect of speaking rate on the data from each variety (rather than on the speech of each individual).[1]

3. RESULTS

3.1 *Establishing the speaking rate effect*

It was important to establish from the beginning that the speakers did make a difference between fast and normal speaking rate. Since rate is difficult to control for long stretches of speech, the unit used to establish speaking rate in the present data was the test-word.

Table 2: Mean test-word durations and standard deviations in CYG and SG, by intervocalic consonant.

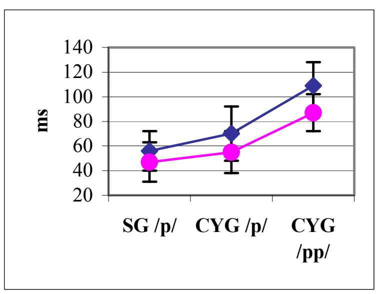
	SG		**CYG singletons**		**CYG geminates**	
Phone	Mean	S.D.	Mean	S.D.	Mean	S.D.
/p/ normal	293	41	361	37	397	39
/p/ fast	232	45	301	40	317	39
/t/ normal	281	36	371	44	427	58
/t/ fast	229	35	308	44	341	55
/k/ normal	292	37	379	40	411	56
/k/ fast	247	35	321	33	334	32
/s/ normal	276	36	379	41	427	66
/s/ fast	230	35	304	49	328	37
/m/ normal	292	34	366	43	331	70
/m/ fast	240	31	303	31	274	54
/n/ normal	274	35	335	48	426	63
/n/ fast	221	36	275	40	334	56
/l/ normal	278	40	330	41	398	82
/l/ fast	226	42	277	42	324	61
/r/ normal	276	35	331	37	418	52
/r/ fast	218	33	274	44	342	51

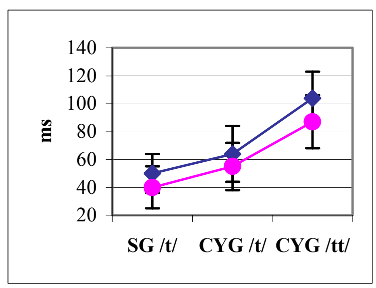
[1] The fact that SPEAKER was not one of the factors in the ANOVAs presented here means that some of the statistical results in this paper differ slightly from those presented in Tserdanelis & Arvaniti (this volume). In that study SPEAKER was a *random effects* ANOVA factor, a setting that changes the significance level of certain statistical results.

As the data in Table 2 show, the test-words were shorter in fast than in normal speaking rate [for /p/, $F(1,282)=198.6$; for /t/, $F(1,282)=153.15$; for /k/, $F(1,282)=166.32$; for /s/, $F(1,282)=188.8$; for /m/, $F(1,282)=112.12$; for /n/, $F(1,282)=150.15$; for /l/, $F(1,282)=90.44$; for /r/, $F(1,282)=159.67$; $p<0.001$ in all cases]. For the SG data and for the CYG words with intervocalic singletons, the reduction of the word duration in fast speech ranged from 18-27%; for the CYG words with intervocalic geminates, the reduction ranged from 21-30%. These results suggest that the differences between rates were perceptually relevant, since they were above Just Noticeable Difference (Lehiste, 1970; Klatt, 1976). Finally, it is worth noting that the Greek words were shorter than the Cypriot ones, implying that the Greek speakers spoke faster than the Cypriot speakers at both rates.

3.2 *Speaking rate effects on segments*

STOPS: As can be seen in Figure 1, closure duration was shorter in fast than in normal speaking rate [for /p/, $F(1,282)=56.4$; for /t/, $F(1,282)=41.4$; for /k/, $F(1,282)=15.7$; $p<0.0001$ in all cases]. In the data for /p/, there was also interaction between C-TYPE and RATE [$F(2,282)=3.36$, $p<0.04$]; the investigation of this interaction by means of Tukey HSD tests showed that in the SG data there was no difference in /p/ closure duration between rates, while the CYG singletons and geminates showed the expected reduction at fast rate [$p<0.001$ in both cases].





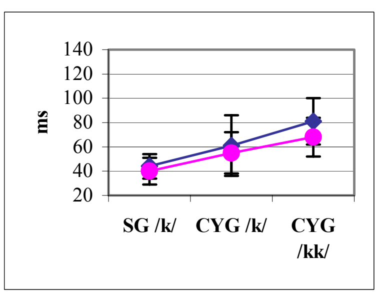
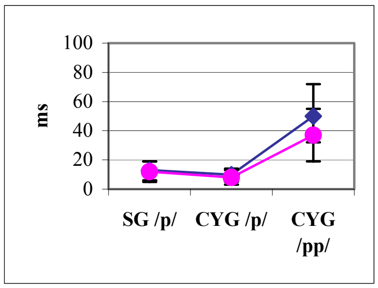
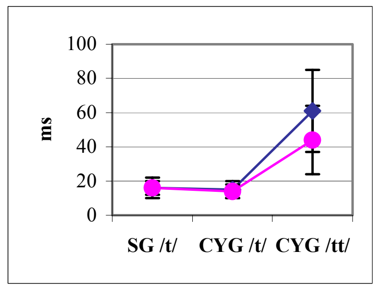


Figure 1: Mean closure durations and standard deviations for stops. Circles show durations at fast rate and diamonds show durations at normal rate.

The VOT data, presented in Figure 2, yielded somewhat different results. Although there was a significant effect of RATE in all cases [for /p/, $F(1,282)=13.7$; for /t/, $F(1,282)=15.05$; for /k/, $F(1,282)=41.8$; $p<0.0001$ in all cases], it is only for /k/ that it holds for all consonant types. For /p/ and /t/ there was interaction between RATE and C-TYPE [for /p/, $F(2,282)=6.4$; $p<0.002$; for /t/, $F(2,282)=13.22$, $p<0.0001$]:

Tukey HSD tests showed that the short-lag VOT of both SG and CYG /p/ and /t/ was not affected by RATE; that is, only the long-lag VOT of the CYG geminate /pp/ and /tt/ was shorter in fast speaking rate [p<0.001 for both].





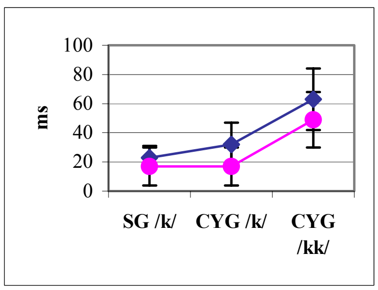


Figure 2: Mean VOT durations and standard deviations for stops. Circles show durations at fast rate and diamonds durations at normal rate.

SONORANTS AND /s/: The sonorants and /s/ yielded similar results (see Table 3 and Figure 3). Specifically, all data showed shorter segmental duration in fast rate [for /s/, $F(1,282)=89.5$; for /m/, $F(1,282)=54.3$; for /n/, $F(1,282)=27.8$; for /l/, $F(1,282)=36.4$; $p<0.0001$ in all cases; for /r/, $F(1,282)=14.4$, $p<0.002$]. However, /s/, /n/ and /r/ also showed interaction between RATE and C-TYPE [for /s/, $F(2,282)=8.4$, $p<0.001$; for /n/, $F(2,282)=3.9$, $p<0.02$; for /r/, $F(2,282)=3.4$; $p<0.04$]. The investigation of these interactions by means of Tukey HSD tests showed that in some cases the segments were of the same duration across speaking rates: this holds for the SG /s/ data, and for the SG and CYG singleton /n/ and /r/ data.

Table 3: Mean durations and standard deviations (in brackets) for /s/ in the two speaking rates, separately for each C-TYPE.

	SG /s/		CYG /s/		CYG /ss/	
Normal rate	100	(18)	134	(24)	166	(38)
Fast rate	88	(12)	103	(22)	127	(23)

3.3 *Comparisons across varieties*

STOPS: Stop closure was in all cases affected by C-TYPE [for /p/, $F(2,282)=186.2$; for /t/, $F(2,282)=217.4$; for /k/, $F(2,282)=84.9$; $p<0.0001$ in all cases]. The differences between the three levels of C-TYPE were investigated by means of planned comparisons, which showed that closure duration was shorter for the SG stops than for the CYG singletons or the CYG geminates (see Figure 1); as shown in

Tserdanelis & Arvaniti (this volume) as well, closure duration was also shorter for CYG singletons than geminates[2]. The only exception to this general pattern were the SG and CYG single /p/, which were of the same duration in fast speaking rate, as indicated by Tukey HSD tests used to investigate the RATE × C-TYPE interaction mentioned in section 3.2.

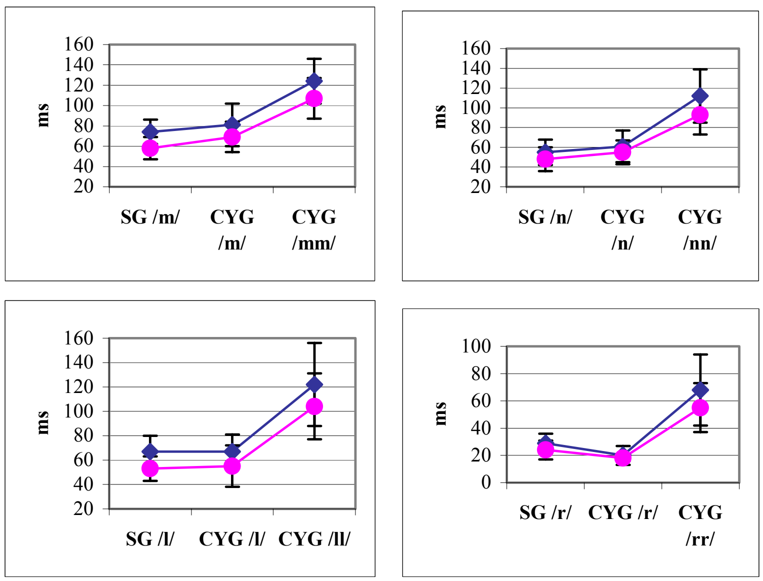


Figure 3: Mean durations and standard deviations of sonorants. Circles show durations at fast rate and diamonds durations at normal rate.

The VOT data also showed a significant effect of C-TYPE [for /p/, $F(2,282)=227.8$; for /t/, $F(2,282)=250.7$; for /k/, $F(2,282)=153.9$; $p<0.0001$ in all cases]. Planned comparisons showed that in all cases the short-lag VOTs of SG and CYG were of similar duration, and that both were shorter than the long-lag VOT of the CYG geminates (see Figure 2). This holds not only for /k/, for which there was no RATE × C-TYPE interaction, but also (according to Tukey HSD tests) for /p/ and /t/, for which there was, as mentioned in 3.2, interaction between RATE and C-TYPE.

SONORANTS AND /s/: The sonorants and /s/ data also showed a significant effect of C-TYPE on duration [for /s/, $F(2,282)=115.2$; for /m/, $F(2,282)=216.95$; for /n/, $F(2,282)=246.8$; for /l/, $F(2,282)=200.7$; for /r/, $F(2,282)=224.1$; $p<0.0001$ in all cases]. For the /m/ and /l/ data, for which there was no C-TYPE × RATE interaction, planned comparisons showed slightly different patterns: specifically, SG /m/ was shorter than both the CYG singleton and the CYG geminate (with the former of

[2] Unlike in Tserdanelis & Arvaniti, the statistical analyses presented here suggest that /k/ closure and VOT are *longer* for the CYG geminates than for the singletons; as mentioned in footnote 1, this discrepancy is due to the slightly different statistical models used in the two studies.

those also being shorter than the latter; see Figure 3); SG /l/, on the other hand, was of similar duration to the CYG singleton, and both were shorter than the CYG geminate. As mentioned in 3.2, in the /n/, /r/ and /s/ data C-TYPE interacted with RATE. The investigation of these interactions by means of Tukey HSD tests showed the following: SG and CYG /n/ and /r/ were of the same duration (within each speaking rate), and they were both shorter than the respective geminates; in both speaking rates, the SG /s/, however, was shorter than the CYG singleton and the CYG geminate (of the two, the former was also significantly shorter than the latter).

4. DISCUSSION AND CONCLUSION

The present results show that in fast speaking rate all phonetic categories shorten, irrespective of the presence of a linguistic contrast. As in Arvaniti (1999), however, this does not hold for the single /r/ which is phonetically a tap; similarly, there is no reduction in the VOT of unaspirated stops, a result that agrees with those of Kessinger & Blumstein (1997), and Fourakis (1986). The invariability of certain categories, such as short-lag VOT, has been used as evidence that one category in a contrast remains invariable, so that no overlap between the values of distinct categories occurs (Kessinger & Blumstein, 1997). The present data however, in combination with those of Arvaniti (1999), clearly show that this is not the case: the timing of a given phonetic category remains invariable only when it is tightly constrained to do so, as happens with taps and short-lag VOT: a tap is a ballistic movement which cannot be shortened (or prolonged) at will (Lindau, 1985); similarly short-lag VOT cannot be prolonged without turning into long-lag VOT, nor can it be shortened without turning negative (Kessinger & Blumstein, 1997).

Moreover, despite the fact that in most cases both the CYG singletons and the CYG geminates shortened at fast rate, planned comparisons on the data show that there is no overlap between geminates spoken at fast rate and singletons spoken at normal rate. In other words, the categories remain distinct, despite the reduction exhibited by both. On the other hand, it must also be noted that the CYG geminates showed greater variability than the singletons in many cases (judging from their standard deviations; c.f. Figures 1-3). This suggests that the long category in the contrast has greater margin for variation, whereas the short category most probably cannot be compressed to the same extent, because it is closer to incompressibility point (Klatt, 1976). This explanation of the observed patterns is further supported by the SG data, which resembled the CYG singleton data in showing small variations under changes of speaking rate, suggesting that incompressibility is indeed at play. Furthermore, the finding that the SG data were not more variable than the CYG data, despite the fact that SG does not have a contrast based on duration, supports the view that the absence of a contrast does not necessarily result in greater phonetic variability and thereby corroborates the conclusions of Arvaniti (1999).

From another point of view, however, the results seem initially at odds with those of Arvaniti (1999). Specifically, in that study the SG segments were of intermediate duration between CYG singletons and geminates, and a hypothesis was advanced (mentioned in section 1) that this was due to the fact that SG does not have a durational distinction, and thus can choose longer canonical values for its sonorants. In the present data, in contrast, the SG segments were shorter than even the CYG singletons. Part of the discrepancy is clearly due to the fact that the Greek subjects in Arvaniti (1999) were slower speakers than those who took part in the experiment reported here: (previously unreported) C-TYPE × RATE ANOVA results show that the test-words in Arvaniti (1999) were longer than CYG words with singleton intervocalic consonants, and of similar duration to the CYG words with *geminates*, whereas in the present experiment the SG words were shorter than both types of CYG words. However, ANOVAs on the proportion of the word's duration occupied by the intervocalic consonant yielded the same results in both the data of Arvaniti (1999) and the present study: the SG proportions were longer than those for CYG singletons and shorter than those for CYG geminates. This suggests that the two linguistic varieties adopt different overall timing strategies, with consonants in SG occupying a larger part of a word's duration than consonants in CYG do (alternatively, one could say that vowels reduce more in SG than in CYG). In addition, the fact that the ANOVAs on proportion show no effect of RATE indicates that changes of speaking rate do not result in radical re-organization of timing relations among segments, but rather in their proportional reduction.

In conclusion, the data show that faster speaking rate results in the shortening of segments, irrespective of the presence of a phonetic contrast, unless tight articulatory constraints regulate the timing of a segment. Further, the finding that the SG data are not more variable than the CYG data indicates that the absence of a linguistic contrast does not necessarily result in greater phonetic variation. Finally, the results of the proportional data strongly suggest that the prosodic organization of the two varieties shows systematic differences that are worth investigating further.

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