# Towards the acoustic analysis of lateral consonants in Modern Greek dialects: a preliminary study

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## 1. Introduction

Published phonetic descriptions of Modern Greek dialects report substantial variation in lateral consonants. Most if not all Modern Greek varieties appear to have several non-contrastive voiced lateral approximants whose distribution is determined by the following vowel. In many varieties palatal [ʎ] or palatalised dental [l$^{j}$] occur before front vowels. In Northern dialects palatal consonant may also occur in word-final position or before a consonant as a result of deletion of etymological unstressed /i/. According to Arvaniti (1999b) in Cyprus speakers may use [ʝ] instead of [ʎ]. Similar pronunciation is attested in some Chios villages (Kontosopoulos 2001). In several varieties including Standard Modern Greek palatal consonant may also occur before back vowels: Ath. [maʎ$^{l}$a] *'hair'*. These cases are usually analysed in studies on Modern Greek phonology as an underlying sequence /li/. The only exception to this trend is Tsakonian where according to Kontosopoulos (Kontosopoulos 2001) /l/ is velarised before [i].

In most part of Epirus, Macedonia and other Northern Greek dialects as well as in Western Crete lateral consonants before back vowels are velarised. Joseph and Tserdanelis (2003) note that this pronunciation serves as a regional identifier for northern speakers. In some varieties including Naxos and Crete velarised [l$^{ɣ}$] had been vocalized into [w].

Furthermore, in Cypriot Greek and other South-Eastern dialects all sonorants including lateral consonants have phonetically long counterparts usually called 'geminates'. Geminate sonorants occur word-medially and word-initially and may be lexical or post-lexical. In some regions of Crete and some Dodecanese dialects words which elsewhere have [l:] are pronounced with [lt] or [ld], while words that elsewhere are pronounced with [l] can be pronounced with an approximant [ɹ] (Kontosopoulos 2001; Joseph and Tserdanelis 2003).

This brief overview shows the width of the reported variation. Yet, most of these descriptions are based on impressionistic observations, and duration and quality of lateral consonants are among the features that constitute a particular challenge for an impressionistic auditory analysis. Therefore an instrumental analysis may substantially improve their description. It is also known from acoustic studies on lateral consonants in other languages that lateral consonants are generally subject to contextual variation, co-articulation and individual variation (Ladefoged and Maddieson 1996). This raises questions about the consistency and scope of the reported phenomena, which can only be answered by a quantitative instrumental study.

Instrumental data on lateral consonants in Modern Greek dialects are only available for Cypriot Greek geminates and laterals in Patras dialects. These studies revealed new aspects of variation in lateral consonants. For example, Papazachariou (2003) showed that in the dialect of Patras regional (more palatalised) pronunciation of /l/ was in free variation with the standard pronunciation. Eftychiou (2008) showed that geminate laterals in Cypriot Greek differed from corresponding singletons not only in duration (see

Arvaniti 1999a, Tserdanelis & Arvaniti 1999, Arvaniti & Tserdanelis 2000, Arvaniti 2001), but also by a consistent differences in quality. She also found that geminate laterals involved a greater amount of linguo-palatal contact, especially word-initially.

In this paper I will look at quality and duration of [l] and [l:] in the three varieties of Greek: Thessalian, Cypriot and Athenian Greek. Thessalian Greek is an example of the Northern dialects and like other Northern Greek dialects, is reported to have 'dark' or 'velarised' [lˠ] before back vowels (Kontosopoulos 2001). Cypriot Greek is an example of the South-Eastern dialects, which distinguish between geminate and singleton laterals. The third variety included in this study is Athenian Greek, which was chosen in order to provide some benchmark data that would be as close as possible to a natural colloquial form of Standard Modern Greek.

The analysis has several goals: to provide a more precise phonetic description of regional features and possibly reveal further differences between the dialects; to separate the truly regional features from processes which occur in colloquial Greek elsewhere; and to compare the patterns of variation between the varieties. I will examine whether spontaneous speech in Cypriot Greek supports the findings obtained on laboratory speech and compare the quality and duration of geminate and singleton laterals in Cypriot Greek to laterals in Athenian and Thessalian Greek. I will also investigate whether the impression of 'dark' [lˠ] reflects the difference in acoustic properties of Thessalian /l/ from /l/ before back vowels in the other two dialects. Finally, I will look at what other factors may affect the duration and quality of lateral consonants in all three varieties.

## 2. Data and measurements.

The study is based on the same corpus as previously described in (Loukina in press). It consists of spontaneous monologues recorded from 21 speakers in Athens, Thessaly (Karditsa) and Cyprus (Nicosia). All speakers belonged to the same age group (75-93 years old), had primary education and were involved in traditional occupations. All speakers from Cyprus and Thessaly were natives of the area. Speakers recorded in Athens lived there at least since 1950s and were not perceived as regional speakers by speakers of Standard Modern Greek.

The analysis is based on the comparison of /l/ (/l:/) in 225 tokens of three highly frequent words shown in

Table . In all cases the lateral consonant is in pre-stress position word-medially, surrounded by back vowels.

Table 1. *List of tokens with Athenian, Thessalian and Cypriot pronunciation, Standard Greek spelling and English translation.*

| Token | Athenian | Thessalian | Cypriot | Greek spelling | English |
|---|---|---|---|---|---|
| *kala* | [kalˡa] | [kalˡa] | [kalˡa] | καλά | well, good |
| *polla* | [pɔlˡa] | [pulˡa] | [pɔlːˡa] | πολλά | many |
| *poli* | [pɔlˡi] | [pulˡi] | | πολύ | a lot |

The geminate lateral in Cypriot [pɔlːˡa] is lexical and is reflected in the spelling. In Cypriot Greek [pɔlːˡa] is used for Standard Modern Greek [pɔlˡi]. Although some of the speakers occasionally used the standard form [pɔlˡi], the number of occurrences was low and therefore the Cypriot data for this word was not included into the analysis. In Thessalian Greek etymological unstressed /o/ has the same distribution of frequencies of F1 as the stressed /u/ and significantly higher than the F1 frequency of unstressed /o/ in Athenian or Cypriot Greek (Loukina in press).

All tokens of these words were saved as separate sound files and analysed using Wavesurfer[1] speech processing software. The tokens were manually segmented into phones. For the purpose of this study following Peterson and Lehiste (1960) /l/ was identified based on the changes in formant frequencies and amplitude. The durations were automatically extracted from the labels. Formants were tracked using the formant-tracking function of the software and manually checked against the spectrogram for accuracy. The frequencies of formants were automatically extracted at the interval of 10 ms and the value closest to the middle of the segment was used for further analysis.

Several normalization procedures were applied, including average values discussed by Adank (2004) and *z*-scores as proposed by Lobanov (1971). None of them allowed differences between speakers to be removed while preserving contrast between different sounds. Therefore it was decided in the first instance to use the raw frequencies in Hz, dealing with variation due to speaker and dialect via the statistical tests employed rather than normalization.

## 3. Duration of lateral consonants in Modern Greek dialects.

Table  and *Figure*  show durations of lateral consonants in the three varieties of Greek. A Mann-Whitney U test showed that only in Cypriot Greek was there a consistent significant difference in the duration of /l/ between *polla* and *kala* (120 ms vs. 63 ms, $p<0.001$). This agrees with previous accounts of Cypriot geminates, which showed that geminate laterals in Cypriot are usually longer than the corresponding singletons.

Table 2: *Mean duration of /l/ (ms) in polla and kala in Thessalian, Cypriot and Athenian Greek. The numbers in italics indicate standard deviation.*

| | ***polla*** | ***kala*** | ***poli*** |
|---|---|---|---|
| **Athenian Greek** | 86.7 | 74.9 | 74.1 |
| | *20.5* | *12.6* | *0.23* |
| **Thessalian Greek** | 66 | 64.3 | 63.8 |
| | *21.1* | *13.2* | *0.24* |
| **Cypriot Greek** | 119 | 63.3 | - |
| | *33.9* | *19.2* | - |

Contrary to the results reported by Arvaniti (1999a) based on laboratory speech, in spontaneous speech there was certain overlap in duration between singleton and geminate consonants, but they had very distinct distributions of duration.

Comparison between the varieties showed that there also was significant difference in duration of the lateral consonant in *polla* between Cypriot Greek and the other two varieties (119 ms in Cypriot Greek vs. 66 ms in Thessalian Greek and 87 ms in Athenian Greek, Mann Whitney U tests, $p<0.001$), but no significant differences between the durations of /l/ in *kala*. Furthermore, even though Athenian and Thessalian Greek do not distinguish between geminates and singletons, they did not show greater variation in duration than Cypriot singletons.

There also was no difference in duration between /l/ followed by back vowels and /l/ followed by front vowel in Athenian and Thessalian Greek.

[1] http://www.speech.kth.se/wavesurfer/

## 4. Quality of lateral consonants in Modern Greek dialects.

The frequencies of F1 and F2 of /l/ in the three varieties are shown in *Table* .

Table 3: *Mean F1 and F2 frequencies of /l/ (Hz) in polla, kala and poli in Athenian, Thessalian and Cypriot Greek. The numbers in italics indicate standard deviation.*

| | ***polla*** | | ***kala*** | | ***poli*** | |
|---|---|---|---|---|---|---|
| | **F1** | **F2** | **F1** | **F2** | **F1** | **F2** |
| **Athenian Greek** | 532 | 1490 | 571 | 1441 | 335 | 1690 |
| | *159* | *196* | *159* | *235* | *72* | *246* |
| **Thessalian Greek** | 465 | 1324 | 561 | 1356 | 279 | 1839 |
| | *80* | *232* | *100* | *253* | *42* | *301* |
| **Cypriot Greek** | 355 | 1448 | 480 | 1474 | | |
| | *122* | *153* | *130* | *123* | | |

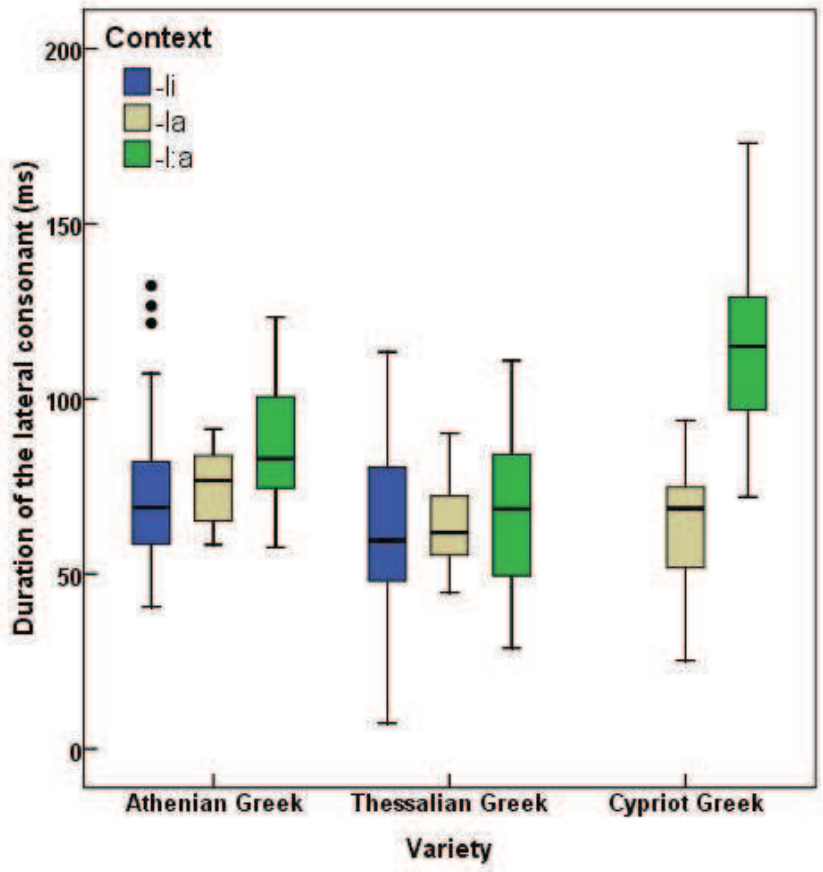


Figure 1: *Distribution of durations of /l/ in kala and polla in Athenian, Cypriot and Thessalian Greek. The boxes show the data between the 25th and 75th percentile, the band near the middle of each box indicate median value. The whiskers indicate the lowest and highest datum within 1.5 of the interquartile range. Black dots indicate the outliers.*

### 4.1. Singletons and geminates.

In Cypriot and in Thessalian Greek there was a significant difference in F1 of /l/ between *polla* and *kala* (355 Hz vs. 480 Hz in Cypriot Greek, 465 vs. 561 Hz in Thessalian Greek, Mann-Whitney U tests in both cases, $p<0.001$). In both these varieties the /l/ in *polla* has a lower F1 than in *kala* (see *Figure* ). The results for Cypriot Greek correspond to

the results obtained on laboratory speech by Eftychiou (2008). She has shown that in Cypriot Greek word-medial geminate /l:/ has a lower F1 and a tendency towards lower F2 than the corresponding singleton. The results of this study confirm that the difference in F1 between singletons and geminates is also present in spontaneous speech; however, in this data sample there was no difference in F2.

In Thessalian Greek /l/ in *polla* had lower F1 than in *kala*. There is no other evidence for contrast between geminate and singleton laterals in Thessalian Greek and there was no difference in duration between lateral consonants in these two words. Therefore it is unlikely that this difference can be explained by the lexical contrast as in case of Cypriot Greek. The more likely explanation is the influence of the preceding vowel. Unlike Athenian Greek, where /l/ is preceded by [ɔ], in Thessalian Greek /l/ is preceded by [u]. This could have resulted in greater difference in F1 between /l/ in *polla* and in *kala*/ in Thessalian Greek than in Athenian Greek. I will discuss the effect of adjacent vowels later in this paper.

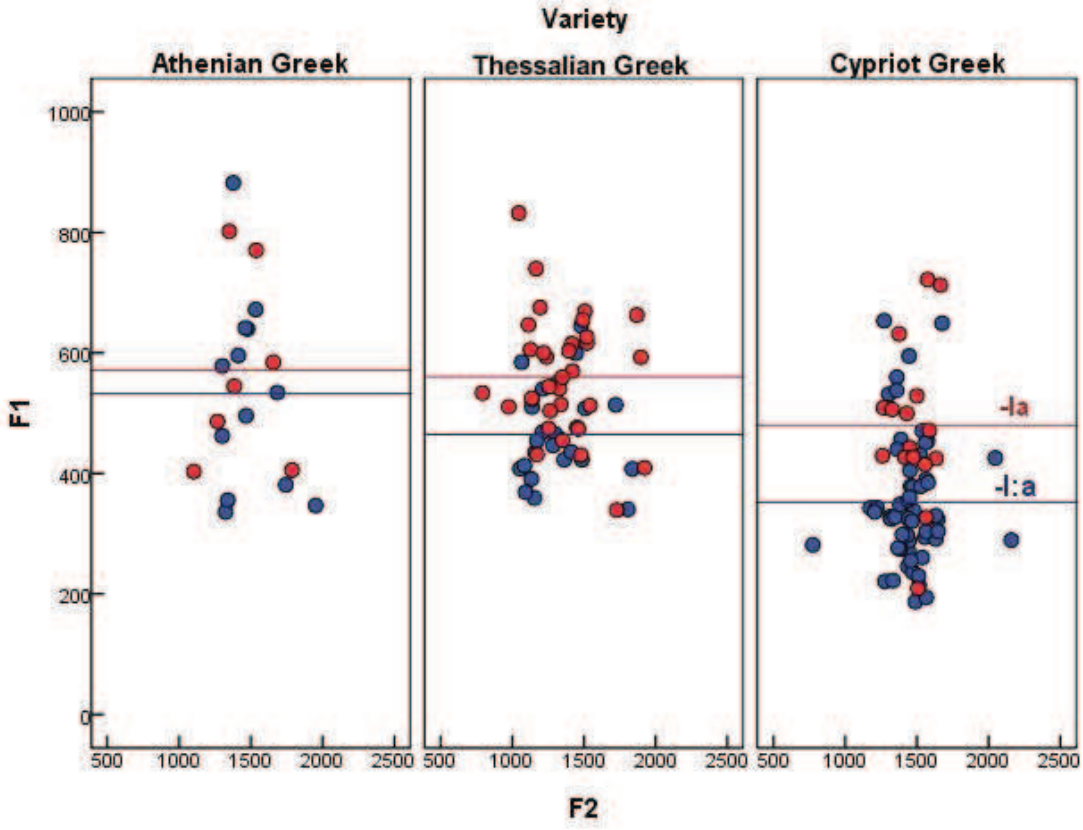


Figure 2: *The frequencies of F1 and F2 (Hz) of /l/ in kala (red) and polla (blue) in Athenian, Thessalian and Cypriot Greek. Horizontal lines indicate mean values for each variety.*

Comparison between the varieties showed that lateral consonants in Cypriot Greek had lower F1 than in Athenian and Thessalian Greek. The geminate /l:/ in Cypriot Greek *polla* had a lower F1 than the singleton /l/ in the same word in Athenian and Thessalian Greek (255 Hz in Cypriot Greek vs. 465 Hz in Thessalian Greek and 532 Hz in Athenian Greek, Mann-Whitney U tests, $p<0.001$). For singletons there was a difference in F1 between Thessalian and Cypriot Greek, with /l/ in Cypriot having a lower F1 (561 Hz vs. 580 Hz, Mann-Whitney U test, $p<0.05$).

## 4.2. Quality of lateral consonants before back and front vowels

Comparison of quality of /l/ before front and back vowels in Athenian and Thessalian Greek[2] showed significant differences in frequencies of both formants depending on the following vowel.

In both varieties the lateral consonant had lower F1 and greater F2 before /i/ than before /a/ (Mann-Whitney U tests in all cases, $p<0.001$. See *Table* and *Figure* ). In *poli* /l/ in Thessalian Greek had higher F2 (1839 Hz vs. 1690 Hz, Mann-Whitney U test, $p<0.05$) and lower F1 than in Athenian Greek (279 Hz vs. 335 Hz, Mann-Whitney U test, $p<0.01$).

Comparison between the varieties showed that in Thessalian Greek /l/ had a lower F2 than in Athenian or in Cypriot Greek in *polla* (1324 Hz vs. 1490 Hz in Athenian Greek, Mann-Whitney U test $p<0.05$, and vs. 1448 Hz in Cypriot Greek, $p<0.001$). The /l/ in *kala* in Thessalian Greek had a lower F2 than in Cypriot Greek (1356 Hz vs. 1474 Hz, Mann-Whitney U test, $p<0.05$), but there was no significant difference from Athenian Greek (possibly due to the low number of Athenian tokens).

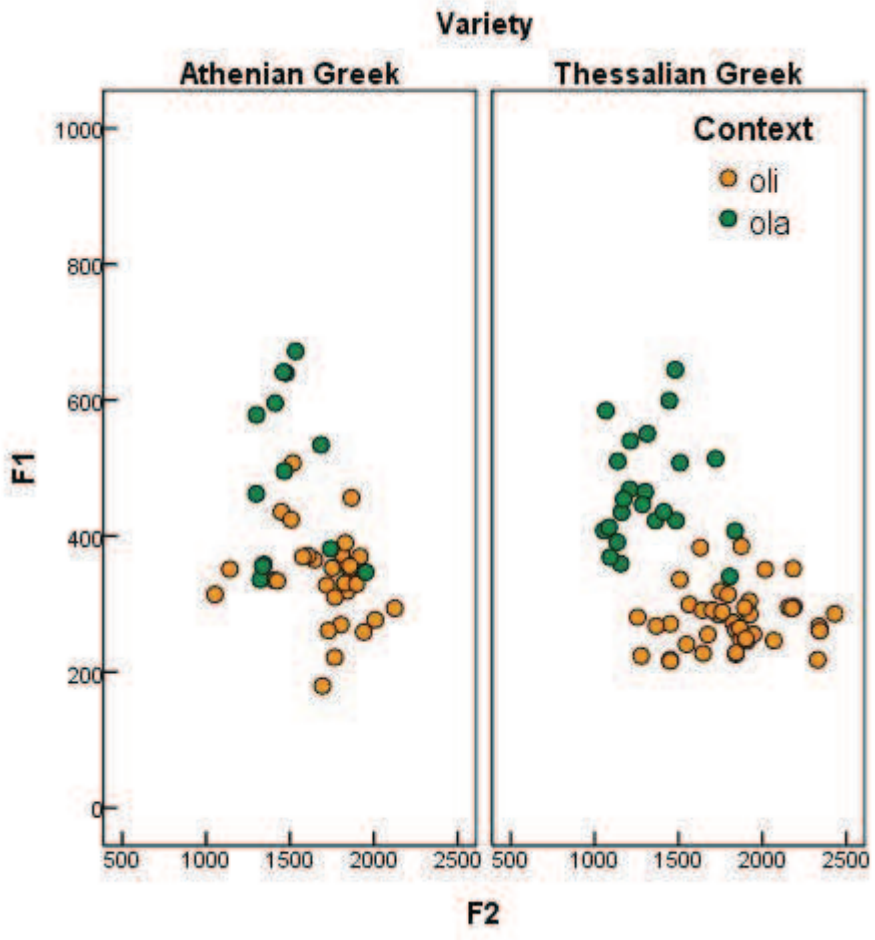


Figure 3: *The frequencies of F1 and F2 (Hz) of /l/ in poli (yellow) and polla (green) in Athenian and Thessalian Greek.*

Lower F2 in lateral consonant may indicate velarisation (Ladefoged and Maddieson 1996). Therefore results of this study agree with the impressionistic observation that Thessalian Greek /l/ before back vowels is 'dark' or velarised ([l$^{\gamma}$]). Acoustic data of course do not provide direct information about the articulation of the consonant, so I will

[2] The data sample contained no Cypriot words where /l/ occurred before front vowels.

use the term 'velarised' as a description of the acoustic quality rather than articulatory feature. Higher F2 observed in Thessalian Greek before /i/ may indicate palatalisiation.

It appears that both the 'velarisation' and the 'palatalisation' of /l/ in Thessalian Greek is subject to individual variation. Before /a/, two speakers had a consistently low F2, for others there was much more variation in values. For two speakers who showed consistent velarisation of /l/, mean frequencies of F2 were 1061 Hz and 1138 Hz, which is similar to the values reported for American English 'dark' /l/ (see, for example, Huffman 1997). For three Thessalian speakers, in whose data the F2 frequency of /l/ before /a/ was comparable to the Athenian speakers (mean F2 for three Thessalian speakers 1394 Hz, cf. 1490 Hz for Athenian speakers), /l/ before /i/ had significantly higher F2 frequency than the F2 of /l/ of the Athenian speakers (1968 Hz in Thessalian Greek vs. 1690 Hz in Athenian Greek).

As a result, mean difference between F2 of /l/ before /a/ and /i/ for each speaker of Thessalian Greek was 585 Hz compared to 295 Hz in Athenian Greek. Therefore in Thessalian Greek the two variants of /l/ acoustically are further apart than in Athenian Greek, which depending on the speaker can be the result of 'velarisation' or 'palatalisation' of /l/ or both of these processes.

## 5. Towards acoustic model of Modern Greek laterals

In the previous sections I suggested that the quality of /l/ in Modern Greek dialects may vary depending on the quality of the following vowel. In this section I will use correlations and multiple linear regression to explore the contribution of F1 and F2 of the adjacent vowels and of the duration of /l/ to the quality of /l/.

The following results are based on a series of multiple linear regressions using the enter method with the F1 or F2 of /l/ as the dependent variables and the following independent variables: F1 and F2 of the preceding and following vowel, duration of /l/ and speaker (recoded into several binary variables).

### 5.1. Athenian Greek

Multiple regression analysis using the enter method showed that in Athenian Greek about 60% of variation in F1 of /l/ could be explained by F1 of the preceding and following vowel (adjusted R square=0.575, $F_{5,42}$=11.354, $p$<0.001, see Table 4 for coefficients of significant variables). Some variation in F2 frequency of /l/ could be explained by the quality of the following vowel (adjusted R square=0.146, $F_{5,41}$=2.569, $p$<0.05, see Table 4 for coefficients of significant variables).

The effect of the adjacent vowels was mainly due to the difference in the quality of /l/ between front and back vowels. Only in *poli* the frequency of F1 of /l/ was positively correlated with F1 of the following /i/ (Pearson's $r$=0.634, $p$<0.001) and the preceding /o/ (Pearson's $r$=0.447, $p$<0.05). There also was positive correlation in F1 between the two vowels (Pearson's $r$=0.500, $p$<0.01), which may suggest greater degree of coarticulation in this word. The variation in quality of the following /a/ appeared to have no effect on the quality of /l/. There also was no effect of duration.

Table 4: *Significant predictor variables in multiple regression analysis in Athenian Greek.*

| **Predictor variable** | **F1 of /l/** | | **F2 of /l/** | |
|---|---|---|---|---|
| | **Beta** | ***p*** | **Beta** | ***p*** |
| Duration of /l/ | | | | |
| F1 (preceding vowel) | 0.354 | $p < 0.01$ | | |
| F1 (following vowel) | 0.540 | $p < 0.001$ | -0.477 | $p < 0.01$ |
| F2 (preceding vowel) | | | | |
| F2 (following vowel) | | | 0.325 | $p < 0.05$ |
| **Adjusted R square** | **0.575** | | **0.146** | |

## 5.2. Thessalian Greek

In Thessalian Greek most variation (83%) in F1 frequency of /l/ could be explained by F1 of adjacent vowels and duration of /l/ (adjusted R square=0.827, $F_{5,90}$=92.045, $p$<0.001, see *Table* for coefficients of significant variables). The frequency of F2 of /l/ was also significantly affected by the quality of the adjacent vowels (adjusted R square=0.507, $F_{5,89}$=20.370, $p$<0.001, see

Table for coefficients of significant variables). I have previously reported inter-speaker variation in F2 in Thessalian Greek. Further analysis showed that differences between speakers account for about 13% of variation: the model that included "speakers" explained 66% of variance (adjusted R square=0.663, $F_{10,84}$=19.501, $p$<0.001).

As in Athenian Greek, the variation in the quality of /l/ was mainly due to different preceding/following vowel[3]. In some cases, sub-phonemic variation in F1 or F2 of the preceding or following vowel also had an effect on the quality of /l/. In *kala* the F1 frequency of /l/ was positively correlated with F1 of the preceding (Pearson's $r$=0.633, $p$<0.001) and following (Pearson's $r$=0.636, $p$<0.001) /a/. As in case of *poli* in Athenian Greek, there also was positive correlation in F1 between the two vowels (Pearson's $r$=0.54, $p$<0.01) in *kala* in Thessalian Greek. In *poli* F2 of /l/ was positively correlated with F2 of the following /i/ (Pearson's $r$=0.525, $p$<0.001). In *polla* and *kala* the F2 frequency of /l/ was positively correlated with F2 of the previous vowel: Pearson's $r$=0.641, $p$<0.01 in *polla* and Pearson's $r$=0.470, $p$<0.01 in *kala.*

Table 5: *Significant predictor variables in multiple regression analysis in Thessalian Greek.*

| **Predictor variable** | **F1 of /l/** | | **F2 of /l/** | |
|---|---|---|---|---|
| | **Beta** | ***p*** | **Beta** | ***p*** |
| Duration of /l/ | -0.154 | $p < 0.01$ | | |
| F1 (preceding vowel) | 0.512 | $p < 0.001$ | -0.228 | $p < 0.05$ |
| F1 (following vowel) | 0.481 | $p < 0.001$ | -0.489 | $p < 0.001$ |
| F2 (preceding vowel) | -0.109 | $p < 0.05$ | 0.261 | $p < 0.01$ |
| F2 (following vowel) | | | 0.255 | $p < 0.01$ |
| **Adjusted R square** | **0.827** | | **0.507** | |

In Thessalian Greek, frequency of F1 decreased with increase in duration: in *poli* and *polla* there was significant correlation between duration and F1 frequency (*poli* Pearson's $r$=-0.345, $p$<0.05, *polla* Pearson's $r$=-0.539, $p$<0.01).

[3] It should be remembered that the first vowel in *poli* and *polla* has significantly lower F1 in Thessalian Greek than in Athenian Greek (Loukina 2008; in press).

### 5.3. Cypriot Greek

In Cypriot Greek some variation in F1 of /l/ could be explained by duration (adjusted R square=0.276, $F_{5,63}$=6.185, $p$<0.001, see Table 6 for coefficients of significant variables). This reflects the difference between geminates and singletons. There was no further correlation between duration and F1 within each of these categories, that is unlike in Thessalian Greek, in Cypriot Greek lower F1 in geminate consonants was not associated with longer duration. There also was a weak effect of F2 of the following vowel.

The effect of adjacent vowels on F2 of /l/ in Cypriot Greek differed between singletons and geminates. In *kala* F2 of /l/ was correlated with the quality of the preceding (F1: Pearson's $r$=0.638, $p$<0.05, F2: Pearson's $r$=0.761, $p$<0.01) and the following vowel (F1: Pearson's $r$=0.622, $p$<0.05, F2: Pearson's $r$=0.650, $p$<0.05). There were no such correlations in *polla.*

Table 6: *Significant predictor variables in multiple regression analysis in Cypriot Greek.*

| **Predictor variable** | **F1 of /l/** | | **F2 of /l/** | |
|---|---|---|---|---|
| | **Beta** | ***p*** | **Beta** | ***p*** |
| Duration of /l/ | -0.346 | $p$ < 0.01 | | |
| F1 (preceding vowel) | | | | |
| F1 (following vowel) | | | | |
| F2 (preceding vowel) | | | | |
| F2 (following vowel) | 0.248 | $p$ < 0.05 | | |
| **Adjusted R square** | **0.276** | | **0.066, $p$ = 0.094** | |

It could be argued that smaller effect of adjacent vowels on the quality of /l/ in Cypriot Greek than in the other two varieties is due to the unbalanced sample: in Cypriot Greek there were no tokens of /l/ before /i/. To test this hypothesis I ran multiple regression analysis on a subset of Thessalian data that only contained tokens of *polla* and *kala*[4]. The results showed that in Thessalian Greek quality of the adjacent vowels accounted for 60% of variation in F1 (adjusted R square=0.602, $F_{5,48}$=17.063, $p$<0.001, see *Table* for coefficients of significant variables) and 24% of variation in F2 of /l/ (adjusted R square=0.243, $F_{5,48}$=4.409, $p$<0.001, see *Table* for coefficients of significant variables). This is substantially greater than in Cypriot Greek, which suggests that the observed difference is not an artefact of the sampling method.

Table 7: *Significant predictor variables in multiple regression analysis on a subset of data in Thessalian Greek where /l/ only occurred before /a/.*

| **Predictor variable** | **F1 of /l/** | | **F2 of /l/** | |
|---|---|---|---|---|
| | **Beta** | ***p*** | **Beta** | ***p*** |
| Duration of /l/ | -0.275 | $p$ < 0.01 | | |
| F1 (preceding vowel) | 0.830 | $p$ < 0.001 | -0.454 | p < 0.05 |
| F1 (following vowel) | 0.206 | $p$ < 0.05 | | |
| F2 (preceding vowel) | -0.343 | $p$ < 0.01 | 0.746 | p < 0.0001 |
| F2 (following vowel) | | | | |
| **Adjusted R square** | **0.602** | | **0.243** | |

## 6. Discussion

Acoustic analysis of lateral consonants in three varieties of Modern Greek revealed different patterns of variation in duration and quality.

[4] The number of observations in Athenian Greek was insufficient for the number of predictor variables used in this analysis.

In Cypriot Greek variation in lateral consonants was primarily linked to the contrast between the so-called geminates and singletons. The analysis of spontaneous speech confirmed differences in duration and F1 previously reported for laboratory speech (Payne and Eftychiou 2006, Eftychiou 2008); however, in this data sample there was no difference in F2 between singleton and geminate laterals. There was an overlap between geminates and singletons both in duration and in quality and no evidence for compensatory relations between them. In her EPG study, Eftychiou (2008) found positive correlation between the amount of contact and duration in Cypriot lateral geminates and raised the question whether the difference in quality between geminates and singletons is the result of temporal difference or a distinct gesture (cf. also Payne 2005; 2006 for the discussion of Italian geminates). In this data there was no correlation between F1 and duration in Cypriot geminates. Noteworthy, in Thessalian Greek, which does not exhibit contrast between geminates and singletons, the variation in F1 frequency of /l/ was correlated with duration: longer consonants had lower F1. The results for Thessalian Greek agree with the temporal explanation: longer consonants allowed for more complete execution of the gesture. The absence of such correlation in Cypriot Greek points towards the independent roles of duration and quality as acoustic correlates of germination in Cypriot Greek.

As expected, the data for Athenian and Thessalian Greek did not show any differences in duration or quality between words spelled with single or double consonants. Despite a lack of contrast between geminates and singletons, laterals in Athenian and Thessalian Greek did not show greater variation in duration or F1 frequency than Cypriot singletons. This shows that the limits of variation are not necessarily determined by the requirement to preserve contrast.

In Athenian and Thessalian Greek variation in lateral consonants was linked to the quality of the following vowel. In both varieties there was significant difference in quality of laterals before /i/ and /a/. The results provided experimental evidence for the existence of [lˠ] in Thessalian Greek, which has been often mentioned in impressionistic descriptions. The analysis also revealed significant difference in quality of /l/ before /i/ in Athenian and Thessalian Greek, which may reflect greater palatalisation in Thessalian. In both cases in Thessalian Greek there was individual variation in choice of the variants, but the two variants of /l/ for each individual speaker were consistently further apart in Thessalian Greek than in Athenian Greek. This poses in interesting question: why the velarisation of /l/ is perceived as a more salient dialectal marker than the palatalisation? It may be that it is geographically less widespread than the velarised variant. For example, Kontosopoulos (Kontosopoulos 2001) mentions what can be interpreted as palatalisation of /l/ and /n/ before front vowels "in many parts of Northern Greece, which have not yet been precisely defined by the dialectologists". It may also be that after velarisation had become a stereotype of Northern speech (cf. Labov 1972), it is perceived more readily than palatalisation. The results of this study suggest that the difference between the two variants may be a better measure of comparison between the varieties than acoustic properties of individual sounds, since such difference appears to be more consistent across individual speakers.

It is worth noting that most others Balkan languages once spoken in the same area as Thessalian Greek distinguish between the so-called 'soft'/lʲ/ and 'hard' /□□/ (see also Jakobson 1931 for a broader discussion of such contrast), including Bulgarian (Tilkov & Boiadzhiev 1981), Macedonian (Minissi *et al*. 1982, Sawicka 2009), Albanian (Kaminskaia 2000), and Aromanian (Lazarou 1986, Kramer 1989, Katsanes & Dinas 1990, Koltsidas 1993).

Experimental phonetic data are only available for Bulgarian. Tilkov and Boiadzhiev (1981) give the following formant frequencies for 'hard' [lˠ]: F1=400 Hz, F2=1000 Hz.

'Soft' /lʲ/ has a higher F2 and according the Tilkov & Boiadzhiev the difference in F2 between the two consonants is about 800-1000 Hz (cf. 585 Hz in Thessalian Greek). The F2 of /l/ in my data sample is intermediate to the values given by Tilkov and Boiadzhiev, with Thessalian Greek /l/ before /a/ (F2=1324 Hz) being closer to 'hard' Bulgarian [lˠ] than the other two varieties. Thessalian /l/ before /i/ (F2=1839 Hz) is also closer to 'soft' Bulgarian [ʎ] than Athenian Greek. It is likely that the existence of opposition of velarised and palatalised laterals in contact languages contributed to the polarisation of variants of /l/ before back and front vowels in Thessalian Greek.

Sawicka (Sawicka 1997, 2009) suggested that this area of Balkans can be described as characterized by accommodative pronunciation with frequent assimilations and neutralizations. Although one should be cautious when trying to fit all phonetic processes of a given language under single generalization, the results of this study suggest that in Thessalian Greek /l/ is subject to greater coarticulatory effects than in the other two varieties. Quality of adjacent vowels and duration explained 83% of variation in F1 of /l/ in Thessalian Greek, 58% of variation in Athenian Greek and only 28% of variation in Cypriot Greek.

Sproat and Fujimura (1993) suggested that the variation between dark and clear /l/ in English is a result of different phonetic implementation of the same phonological entity depending on the position and duration (cf. also Huffman 1997 for further discussion). They argue that English variation between dark and clear /l/ is continuous and phonetically predictable and there is no need to use distinct phonological units to encode this variation. The results of this study also suggest that the variation in quality /l/ can partially be explained by such factors as the quality of the adjacent vowels and duration. However, the effect of these factors differed across varieties. The effect of the adjacent vowels was very limited in Cypriot Greek, where most of variation was governed by the lexical distinction between geminates and singletons. To the contrary, in Thessalian Greek most of variation in the quality /l/ in this data could be explained by phonetic factors. Further study is needed to establish whether this is true for other positions and contexts. In Athenian Greek the main pattern of variation was similar to the Thessalian Greek, yet the range of variation was significantly smaller and there was less effect of adjacent vowels and no effect of duration. This suggests that such phonetic processes as coarticulation or gestural undershoot may operate to a different degree even in closely related varieties and raises the question of what factors may block or encourage their application.

## 7. Conclusion

The results reported in this paper are based on a very limited data sample and therefore should be treated with caution. While the conclusions are thus limited, it should be noted that they agree with the results of previous laboratory studies where such exist. This study once again highlighted the non-durational aspects of geminate consonants and provided experimental evidence for the features that until now have been only described on impressionistic basis. It has also revealed new aspects of variation in lateral consonants in Modern Greek dialects.

While a model of phonetic implementation could explain some variation in lateral consonants, the study showed that the rules of phonetic implementation are certainly language-specific (or even dialect-specific in this case). Although the data for each variety consisted of the same lexical items, the patterns of variation in lateral consonants were very different in the three varieties. This once again shows the complexity of interaction between universal physiological principles of speech production and language-specific constraints (cf. also Loukina 2009). There is no doubt that further studies on larger

corpora of data from different varieties where lateral consonants would occur in more phonological contexts, different positions and stress conditions will contribute to better understanding not only of differences between Modern Greek dialects and but also general principles of speech production.

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