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GREEK TS/DZ AS INTERNALLY COMPLEX SEGMENTS: PHONOLOGICAL AND PHONETIC EVIDENCE[*]

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Abstract

The "affricate dream" of Householder (1964), in which Modern Greek *ts*/*dz* are reduced to clusters of independently occurring segments (thus, *ts* is analyzed as /t + s/), is examined here in the light of two types of evidence not previously considered: instrumental measurements of the duration of the sounds in question

compared with related sounds, and the proper formulation of a dissimilatory dialectal sound change. This evidence shows that the best analysis recognizes these sounds as single segments but with internal complexity, as suggested, but not overtly argued for, in Joseph & Philippaki-Warburton (1987).

1.   Introduction

A long-standing problem in Modern Greek phonology concerns the analysis of the voiceless dental *ts* and its voiced counterpart *dz*.[1] Like similar sounds in many of the languages of the world, Modern Greek *ts* and *dz* show some characteristics that align them with other stop + sibilant clusters—in particular, *ps* and *ks*. At the same time, though, they present some traits that differentiate them from these clusters, thus suggesting status as single segments (i.e. $[t^s]/[d^z]$). Householder (1964) labeled attempts by linguists to reduce these sounds to clusters of independent segments, as illustrated in (1), the "affricate dream":[2]

> (1)   *ts* = /t/ + /s/   *dz* = /d/ + /z/

Some version of the affricate dream is generally preferred, for instance by Newton (1961, 1972), Setatos (1974), Arvaniti (1999), and Malikouti-Drachman (2001), though there are dissenters who accept the affricate analysis (e.g. Householder himself).

Among the indicators of cluster-like status are the following considerations. First, the range of clustering possibilities that voiceless stops enter into with fricatives shows a gap in the dentals. *p* + *s* and *k* + *s* both occur quite commonly, and even the combination of *t* + θ occurs marginally, as the examples in (2) indicate. A cluster analysis of Greek *ts* would thus fill this gap.[3]

> (2)   kséro   'know'   psélno   'chant'   atθís 'Attica' tsimbó 'pinch'
>   aksía   'value' tapsí   'pan'   (underwear   kutsós 'lame'
>   flóks   'fire'   kónops   'mosquito'   brand name)   bats   'slapping noise'

Second, a cluster analysis of *ts* as *t* + *s* explains an otherwise curious fact about *ts*. Greek tolerates a fairly wide range of clusters involving voiceless stops, including, in word-initial position, the sequences [str-, spr-, skr-, skl-, skn-, tm-, pn-, kn-, tr-, pr-, kr-], among others. However, *ts*, as well as *dz*, for that matter, does not participate in any clustering possibilities: for example, there are no words with *tsr- or *tsl-. In this way,

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[1] Throughout we write these sounds in italics when referring to them in a nontechnical way, since the use of slashes or square brackets would imply that certain analytic decisions had been made, when in fact the point of this exercise is to explore some evidence relevant for those decisions.

[2] Some details of the claims regarding the voiced *dz* depend on other assumptions and claims that go well beyond the rather limited scope of this paper. Other possibilities exist for *dz*, depending on the resolution of Householder's "voiced stop dream" (by which the voiced stops of Greek are reduced to sequences of nasal + voiceless stop), e.g. /nt/ + /z/ or even /d/ (or /nt/) + /s/.

[3] As a result of the phonotactics of colloquial Greek, word-final examples of *ps* and *ks* do not occur; the examples given are from the "high-style", generally literary, variety of Greek known as *katharevousa*. The example with word-final *ts* is an onomatope, though now some loanwords, e.g. *mats* '(football) match', have this sequence also.

ts, and *dz* too, pattern with the clear voiceless stop + sibilant clusters, for there are no Greek words with *psr-, *psl-, *ksr-, *ksl-.

Running counter to these cluster-like indications for *ts* and *dz*, though, are a few facts that show these sounds to be different from *ps* and *ks*. From the standpoint of morphophonemics, it is noteworthy that sequences of the sounds that in a cluster analysis would constitute the *ts*, namely *t + s*, behave differently across a morpheme boundary from the sequences *p + s* or *k + s*. The relevant facts are given in (3), where it can be observed that the combination of morpheme-final *t* plus morpheme-initial *s* yields an *s*, whereas similar sequences with the labial or the velar voiceless stop yield clusters.

(3)   fó<u>s</u>   <= /fot + s/ ('light' + NtrNomSg; cf. NtrNomPl *fót-a*)
        θé<u>s</u>ame   <= /θét + s + ame/ ('put + Prfve + 1PlPst; cf. Pres *θét-ome*)
        próvle<u>ps</u>a   <= /provlep + s + a/ ('foresee' + Prfve + 1SgPst)
        plék<u>s</u>ame   <= /plek + s + a/ ('knit + Prfve + 1PlPst)

Similarly, there are suffixes that begin with *ts* or *dz*, e.g. the hypocoristic *–tsos* and the occupational *–dzis*, as given in (4):[4]

(4)   Mí-tsos   'Jimmy' (from *Đimítris*)
        Kó-tsos   'Connie' (from *Konstandínos*)
        taksi-dzís   'taxi-driver'

There are, however, no suffixes that begin with *ps* or *ks*. It is significant, moreover, that here are suffixes with initial clusters, e.g. the feminine actor-noun suffix, as in (5):

(5)   tilefoní-tria 'telephone operator' (cf. *tilefóni-sa* 'I telephoned')

What this shows is that the absence of *ps* and *ks* from suffix-initial position is not a systematic fact about clusters in general in Greek but rather seems to be a matter relevant only to clusters with sibilant second members. That is, no Greek suffix begins with a stop + sibilant cluster; thus, since *–tsos* and *–dzis* occur, *ts* and *dz* by this criterion cannot be clusters.

Given these conflicting characteristics, it is not surprising that the rather considerable literature on this subject in Greek shows conflicting conclusions on the part of various analysts. In general, linguists have arbitrarily given more weight to one or the other type of behavior and have drawn their conclusions accordingly. For example, as noted above, Newton (1961, 1972), Setatos (1974), Arvaniti (1999), and Malikouti-Drachman (2001) all opt for a cluster analysis,[5] while Householder (1964), on the basis of the morphophonemic evidence, opts ultimately for the single-segment analysis.

A solution to this dilemma was suggested by Joseph & Philippaki-Warburton (1987: 238), where it was proposed that, like affricates in many languages, Modern Greek

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[4] Actually, the occupational suffix, of Turkish origin, also has a *–ts*-initial allomorph after voiceless stops, e.g. *kaik-tsis* 'owner of a *kaiki* (a type of boat)'.
[5] Either overtly stating they are so doing, or adopting it implicitly, via the absence of any mention of affricates in the phonemic inventory.

ts and *dz* constitute single segments but with a complex internal structure.[6] Such an internally complex segment, as represented in segmental ("linear") phonology, following Campbell (1974), is given in (6).

(6)   *ts* = [[t] [s]]   *dz* = [[d] [z]][7]

One possible reinterpretation of this notion autosegmentally is given in (7) for *ts*, with a similar representation for *dz*.

(7)   CV-tier   C   (one element, i.e., unitary)
                                 / \
       Segmental tier   t   s   (two elements, i.e., complex)

However, Joseph & Philippaki-Warburton (1987) merely asserted this possibility as a way out of the dilemma without giving any definitive argumentation to support this claim, beyond the observation that it allows these elements to have properties of both clusters and nonclusters. Accordingly, we present here one type of argument to support the Joseph & Philippaki-Warburton proposal—namely, the phonetic evidence concerning the duration of *ts* and *dz*. We present as well some diachronic evidence from a dialectal sound change that also is consistent with this proposal.

In presenting this evidence, we are attempting to address what has been a difficult problem internal to Greek linguistics—one that has generated considerable debate in the literature—without trying to draw general conclusions about the representation such sounds should or should not have in some particular theoretical framework or other. We do feel, however, that this evidence from one language may well be compatible with similar findings from other languages, and thus relevant for a general theory of complex (or contour) segments cross-linguistically.

2.   Phonetic evidence

In undertaking this investigation, we are working under the assumption — one shared by many linguists, we believe, though not necessarily all — that wherever possible, phonological constructs should be closely tied to the phonetic reality of the elements they represent. Our approach, therefore, closely parallels such work as Hankamer & Lahiri (1986) or Miller (1987), as well as the work that now falls under the general rubric of "laboratory phonology".[8] To gain further insight into the status of Modern Greek *ts* and *dz*, we conducted an experiment involving five native speakers who were graduate students or junior faculty at The Ohio State University. Four spoke Athenian Greek and a fifth, who was fluent in Standard Modern Greek, natively spoke a northern Greek dialect; still, as the results show, dialect was not a factor.

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[6] Or more accurately perhaps in the terminology widely used since Sagey 1986, contour segments (with ordered multiple articulations). Malikouti-Drachman (2001) uses this terminology.

[7] Assuming /d/ as underlying; [[d] [s]] is also possible.

[8] See, for instance, the Cambridge University Press series, *Papers in Laboratory Phonology*, with several volumes based on the now biennial conference on work in this framework, Kingston & Beckman (1991) being the first such volume.

Each speaker read a corpus consisting of fifty-five sets of words, each set containing five words. The words were chosen to give examples of the primary sounds under investigation, *ts* and *dz*, as well as the (presumably) clear clusters *ps* and *ks*, and the single stops and fricatives /p, t, k, s, z/. The sound [d] was not considered because the medial occurrences of [d] was rare for our speakers, often being pronounced, by them as well as by other Greeks, with some degree of prenasalization or with a full preceding nasal. [9] The participant in this experiment had an extremely small number of cases of "pure" [d] (i.e. not accompanied by a nasal in some form).

We recorded their utterances in an anechoic changer and digitized the recordings at 10k Hz. Using a waveform editor, we measured the duration of these consonants in word-medial position. We considered only word-medial consonants for two reasons. [10] First, it is easier to measure these sounds word-medially than word-initially. Second, there is a greater variety of words containing these sounds in medial position than in initial or final position (see footnote 3). Within each five-word set, we measured consonant duration in the second third, and fourth words only, disregarding the first and last words because of possible effects of reading list intonation.

If the duration of *ts* turned out not to be particularly different from that of the stop + sibilant clusters, and if all differed from the single segments, then there would be reason to believe that *ts* and (by extension) *dz* are clusters. If, on the other hand, the duration of *ts* turned out to be quite smaller than that of the clusters, then there would be reason to believe that *ts* and *dz* are not clusters.

The results show that the duration of *ts* was, for all speakers, longer than that of the single segments and, importantly, shorter than that of the clusters /ps/ and /ks/. Figure 1 shows the results for all of the speakers taken together. On average, for all speakers, *ts* was 60.66 ms shorter than /ps/ and 53.04 ms shorter than /ks/. *ts* was 36.24 ms longer than (singleton) /t/ and 17.32 ms longer than (singleton) /s/. T-tests indicate that, for all speakers, the difference between the durations of *ts* and the stop + sibilant clusters was significant at the .01 level.

For all speakers, the difference between *ts* and /t/ was significant at the .05 level. For two speakers, the difference between *ts* and /s/ was significant at the .05 level. For all speakers, the duration of *dz* was on average 41.24 ms longer than /z/; the difference was significant at the .01 level for four speakers. [11]

The experimental results therefore suggest that Greek *ts* and *dz* are not phonetically like clusters, nor are they phonetically like single segments, but rather are in

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[9] See Arvaniti & Joseph (2000, 2002, 2006) for some discussion of trends in the realization of voiced stops in Greek in the past thirty years.

[10] Note that Arvaniti (1987), an instrumental study of clusters in Greek, looked at initial clusters only; see below for brief discussion of her results.

[11] One further comparison was made with [tr] clusters by way of gauging the duration of other combinations with /t/; we found that the [tr] duration for a given speaker was significantly longer than the *ts* duration (p = 0.0236; matched differences t-test, df = 4).

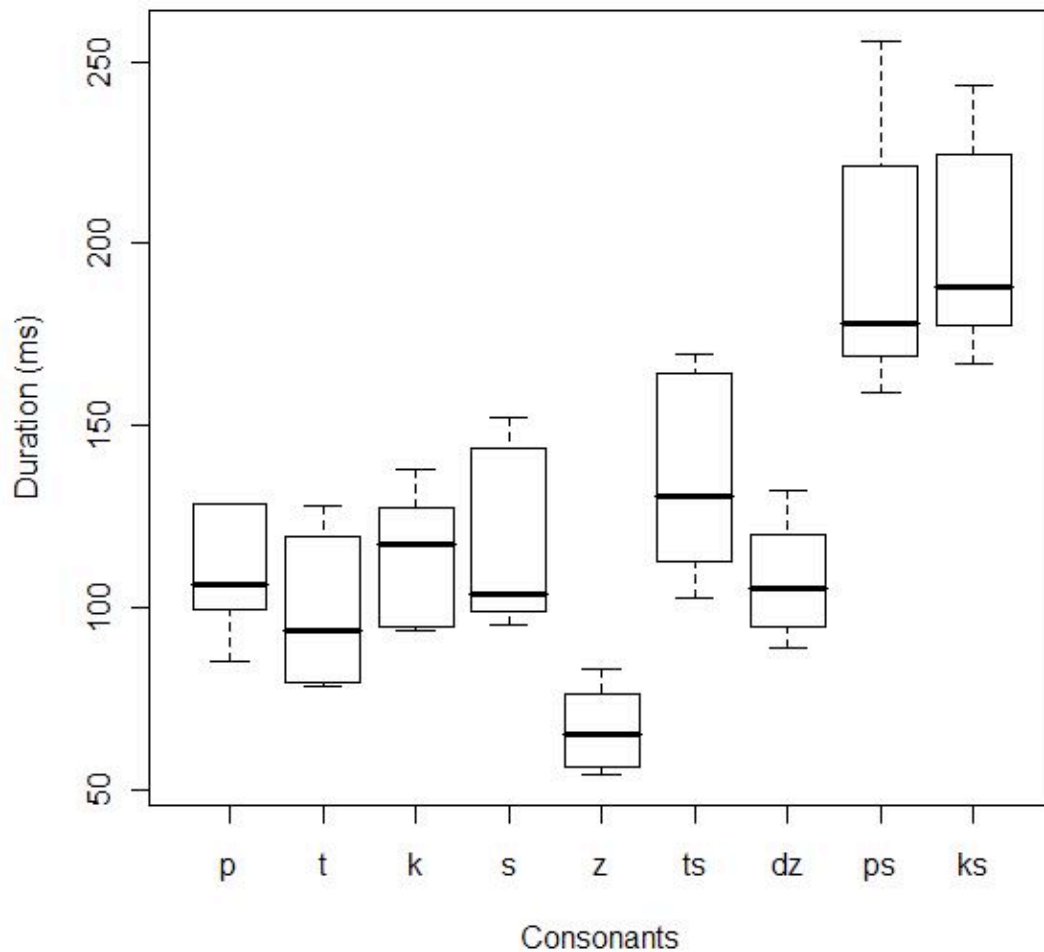between clusters and segments. However, *ts* and *dz* appear phonetically to be more like segments than clusters.

Figure 1. Duration results of all five speakers

As noted above (see footnote *), there are relatively few instrumental studies of Greek that have focused on the "affricate dream", but to some extent they are consistent with what is reported here concerning a different status for *ts*/*dz* from that seen with *ps* and *ks*. Arvaniti (1987: 38), for instance, comments: "The present data seem to suggest (although this is rather speculative) that /ts/ is produced differently from /ps, ks/." Among other things, she notes that "/ts/ as a cluster is significantly shorter than /ps/ and /ks/ for both subjects". Admittedly, the evidence overall is not unproblematic,[12] and one could take a position that the phonetics are not an essential part of a phonological analysis, given that phonology can be taken to deal with abstract units and not the concrete physical realizations per se; nonetheless, the general outlines of the possible contribution of phonetics to the "affricate dream" should be clear.

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[12] As Arvaniti (2002: 115) points out, however, "the shortening observed in [ts] also affects [st] when compared to [sp] and [sk]", and this constitutes a problem for accounts of *ts* that draw on duration evidence.

3. Dialectal evidence from Cypriot

Further support for an analysis of *ts* and *dz* as internally complex ("contour") units comes from some diachronic developments in Cypriot Greek, based on the description given in Pantelides (1923). In a few words, Cypriot [t] corresponds to Standard Greek *ts*, as seen in (8):

(8) t̯itsirízo 'sizzle' (Std. t̠sitsirízo)
  t̯itsín 'meat; breast' (Std. t̠sitsí)

In the words given in (9), Cypriot [t] corresponds to Standard Greek [k], presumably from a prior stage of palatalization to *ts'* (the sound seen farther on in each word in (9), corresponding to Standard Greek [k]/[t] in palatalizing contexts):

(9) t̯irts'éllin 'ring' (Std. k̠rikéli)
  t̯erats'ja 'carob tree' (Std. k̠eratjá)

The diachronic sound change that led to these correspondences involved a dissimilation of [t + s(')] to [t], triggered by a following [t + s(')], and it can be formalized as in (10):

(10) t + s => t / __ ... t + s

This formulation of the change in a cluster analysis of *ts*, however, is rather ad hoc, or at least more complicated than it might be otherwise, in that [t] needs to be stated both in the input and in the conditioning environment. Moreover, /ps/ and /ks/ do not undergo or condition this change. Based on these facts, *ts* and (by extension) *ts'* cannot be clusters.

Furthermore, as (11) indicates, there is a Cypriot word that shows *ts'* (corresponding, again, to Standard Greek [k] via palatalization) dissimilating to [t] in the context of a following [s]:

(11) t̯eparíssin 'cypress tree' (Std. k̠iparísi)

As formalized in (12), under a unitary segment analysis of *ts* as [t͡s] (though the Americanist and Slavist [c] is given below as typographically more congenial here), the change requires an unnatural statement since there is no clear relation between the triggering segment (an [s]) and the change that occurs (c => t):

(12) c => t / __ … s

As seen in (13), however, a more natural rule can be formalized by taking *ts*/*ts'* as internally complex segments, whereby there would be an overtly represented sibilant portion of the complex unit that could be lost via dissimilation in the context of a following sibilant.

(13) [[t] [s(')]] => [[t] [Ø]] / __ … [s]

4.   Conclusion

The two pieces of evidence presented here — the results of instrumental measurements and the diachronic dialectal evidence of a dissimilatory Cypriot sound change — do not by themselves prove the superiority of one analysis of Greek *ts*/*dz* over another, and as some of the discussion above indicates (see especially footnote 12 and some of the references in footnote *), there are problematic aspects to the instrumental analysis. But when considered along with other facts, even in the face of conflicting evidence, each argument is consistent with an analysis of Greek *ts* and *dz* as units that are internally complex, and thus each constitutes a piece in the on-going debate concerning the status of these sounds.

References

Arvaniti, Amalia. 1987. *The Timing of Consonant Clusters: A Study of Initial Consonant Clusters in Modern Greek*. Cambridge: University of Cambridge M.Phil. dissertation.

Arvaniti, Amalia. 1999. Illustrations of the IPA: Modern Greek. *Journal of the International Phonetic Association* 19: 167-172.

Arvaniti, Amalia. 2007. Greek Phonetics: The State of the Art. *Journal of Greek Linguistics* 8: 97-208.

Arvaniti, Amalia & Brian D. Joseph. 2000. Variation in voiced stop prenasalisation in Greek. *Glossologia* 11-12. 131-166. [Preliminary version (1999) in *Ohio State University Working Papers in Linguistics* 52: 203-232.]

Arvaniti, Amalia & Brian D. Joseph. 2002. Modern Greek [b d g] in the early 20c.: Evidence from folk and rebetica songs. *Recherches en linguistique grecque*, vol. I: 67-70. Paris: L' Harmattan.

Arvaniti, Amalia & Brian D. Joseph. 2006. Early Modern Greek /b d g/: Evidence from Rembetika and Folk Songs. *Journal of Modern Greek Studies* 22. 73-94.

Campbell, Lyle. 1974. Phonological features: Problems and proposals. *Language* 50: 52-65.

Fourakis, Marios. 2004. Temporal characteristics of [ps], [ts], and [ks] in Modern Greek. Paper presented at The First (Ever) Martin Luther King Day Symposium on Modern Greek Linguistics, 19 January 2004, Columbus, The Ohio State University.

Fourakis, Marios, Antonis Botinis, & Elena Nigrianaki. 2002. Xronika xaraktiristika ton simfonikon akoluθion [ps], [ts], ke [ks] stin eliniki. *Proceedings of the 6^(th) International Conference on Greek Linguistics* [http://www.philology.uoc.gr/ conferences6thICGL/].

Hankamer, Jorge & Aditi Lahiri. 1986. The timing of underlying and derived geminates. Paper presented at the Annual Meeting of the Linguistic Society of America, New York, December 1986.

Householder, Fred W. 1964. Three dreams of Modern Greek phonology. In Robert Austerlitz (ed.), *Papers in Memory of George C Papageotes* (issued as Supplement to *Word* 20.3), 17-27.

Joseph, Brian D. & Irene Philippaki-Warburton. 1987. *Modern Greek* (Croom Helm Descriptive Grammar Series). London: Croom Helm.

Joseph, Brian D. & Gina M. Lee. 1988. Greek *ts*/*dz* as internally complex segments: Phonological and phonetic evidence. Paper presented at the Annual Meeting of the Linguistic Society of America, New Orleans, December 1988.

Joseph, Brian D. & Georgios Tserdanelis. 2006. On the phonetic description and IPA notation of affricates. Poster presented at the Annual Meeting of the Linguistic Society of America, Albuquerque, January 2006.

Kingston, John & Mary Beckman (eds.) 1991. *Papers in Laboratory Phonology: Between the Grammar and Physics of Speech*. Cambridge: Cambridge University Press.

Malikouti-Drachman, Angeliki. 2001. Greek phonology: A contemporary perspective. Journal of Greek Linguistics 2: 187-243.

Miller, Ann. 1987. Phonetic characteristics of Levantine Arabic geminates with differing morpheme and syllable structures. In Mary Beckman & Gina Lee (eds.) *Papers from the Linguistics Laboratory 1985-1987* (*Ohio State University Working Papers in Linguistics* 36), 120-140.

Newton, Brian. 1961. The rephonemicization of Modern Greek. *Lingua* 10: 275-284.

Newton, Brian. 1972. *The generative interpretation of dialect. A study of Modern Greek phonology*. (Cambridge Studies in Linguistics 8). Cambridge: Cambridge University Press.

Pantelides, X. 1923. Etimolojika ke fonitika. *Leksikografikon Arxion tis Mesis ke Neas Elinikis* 6: 116-124.

Sagey, Elizabeth. 1986. *The representation of features and relations in nonlinear phonology*. Cambridge, MA: MIT Ph.D. dissertation.

Setatos, Michalis. 1974. *Fonolojia tis kinis neoelinikis*. Athens: Papazisis.

Tserdanelis, Georgios. 2005. *The role of segmental sandhi in the parsing of speech: Evidence from Greek*. Columbus, OH: Ohio State University Ph.D. dissertation.