

## Asymmetries of consonant sequences in perception and production: affricates vs. /s/ clusters

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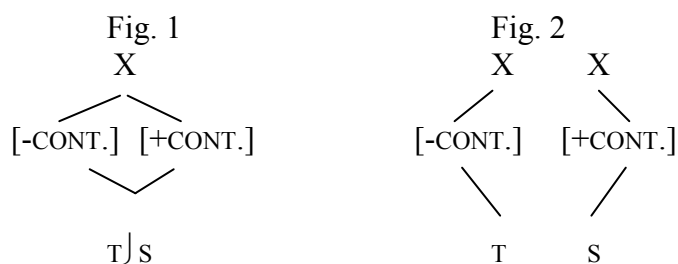
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**Abstract:** This paper investigates the behavior of Greek affricates as opposed to other clusters consisting of /s/ + obstruent and obstruent + /s/ sequences. An experimental task testing the perception of /s/ clusters demonstrated a fixed preference for the preservation of affricates over obstruent +/s/ over /s/ + obstruent clusters. Subjects showed a strong tendency to break up consonantal sequences, while they retained affricates intact. This linguistic behavior is attributed to two factors: a) identity of place of articulation of the members of the examined consonantal sequences and b) satisfaction of the scale of consonantal strength in these sequences.

**Keywords:** cluster, affricate, phonological/ underlying representation, coherence

### 1. Introduction

The phonological representation of affricates is one of the topics of ongoing linguistic debate. The theoretical controversies stemming from the discussion on affricates boil down to two main formal analyses, which result in two different types of underlying representations of affricates. On the one hand, affricates are considered to be monopositional segments with a representation in which the continuancy specifications [+stop] and [+cont] are subordinate to a single root node, as illustrated in fig. 1 (cf. van de Weijer 1995, for Basque; Householder 1964, for Greek). On the other hand, affricates are thought of as consonant clusters consisting of a stop [t] and a fricative [s], as shown in fig. 2 (cf. Σετάτος 1974; Joseph & Philippaki-Warbuton 1987, for Greek). Holton et al. (1997) make no decision regarding these two hypotheses.



We consider both approaches to be insufficiently motivated given that they are based solely on abstract data and do not take actual data into account. In this study we attempt a more thorough investigation of the nature of Greek affricates based on the existing literature as well as actual experimental data drawn from adults, native speakers of Greek. Section 2 consists in a survey of the existing literature, which focuses on a discussion of the standard argumentation regarding the underlying representation of affricates and is based on data from the diachronic and synchronic aspect of Greek. For our discussion we will draw on data from reduplicative-like forms, as well as stem alternation in order to investigate the phonological and morphological factors determining the nature of affricates. Section 3 provides the preliminary conclusions of the discussion in 2. Section 4 highlights the goals of the study, while section 5 presents

the design of the experimental task used for the assessment of the native speakers' perception of different cluster types. Finally, in section 6 we discuss the results of the test and evaluate the subtle differences between the representations of affricates and /s/ clusters. Section 7 concludes the paper and opens issues for further research.

## 2. Phonotactics

### 2.1 Diachrony

Given that Greek affricates are not inherited from ancient Greek (see Browning 1969, Horrocks 1997, among others for a historical overview) it could be suggested that the introduction of [ts] and [dz] in Greek could reveal whether they should be analyzed as one or two phonemes. Words in which output [ts] is related to a single segment are in favor of the hypothesis for the monophonemic nature of affricates (examples taken from Korinthios 1990:16).<sup>1</sup>

- |      |            |   |            |                             |
|------|------------|---|------------|-----------------------------|
| (1a) | /kiros/    | → | [tsiros]   | 'type of bird-ASC.NOM.SG.'  |
| (1b) | /kos:ifos/ | → | [kotsifos] | 'type of bird-MASC.NOM.SG.' |

In (1a), older velar /k/ has been palatalized resulting in output [ts]. In (1b), geminate /s:/ has been changed into the affricate [ts].<sup>2</sup> If affricates in languages like Italian (2a) and Turkish (2b-c) are considered to be single segments, loanwords from these languages containing affricates provide an argument in favor of the hypothesis for the monopositional status of affricates.

- |      |         |   |           |                      |
|------|---------|---|-----------|----------------------|
| (2a) | cozzare | → | [kotsaro] | 'stick-INF.PRES.'    |
| (2b) | çay     | → | [tsai]    | 'tea-NEUT.NOM.SG.'   |
| (2c) | cam     | → | [dzami]   | 'glass-NEUT.NOM.SG.' |

However, there are instances in which [ts] can be reduced to two single segments. Representative examples, taken from Korinthios (1990), are provided in (3) below.

- |      |           |   |           |                           |
|------|-----------|---|-----------|---------------------------|
| (3a) | /iktiðas/ | → | [atsiðas] | 'clever-MASC.ADJ.NOM.SG.' |
| (3b) | /kaθise/  | → | [katse]   | 'sit-2SG.IMP.'            |

In (3a), consonant mutation of /kt/ results in output affricate [ts]. In (3b), on the other hand, the affricate results from /θs/ by means of dissimilation at the continuancy level. /θs/, in turn, is the product of syncope of the intermediate vowel /i/. The general conclusion stemming from the above examples is that diachronic data do not provide clear arguments in favor of the hypothesis which supports the monopositional status of affricates. In the next section, we present more data drawn from reduplication.

### 2.2 Reduplication

An argument frequently cited favoring the monopositional status of affricates comes from reduplicative-like words (see Householder 1964, Pagoni 1994, Kappa 1995, Malikouti-Drachman 2001 among others). It has been argued that in such words only singleton onsets are repeated as shown in (4) (Pagoni 1994).

<sup>1</sup> The examples in (1) exhibit processes that are not widespread in standard Greek. It is possible that they are dialectal borrowings.

<sup>2</sup> The exact analyses of the processes of palatalization and affrication are not of interest for the present study. What matters is whether Greek affricates can be related to a single segment or a cluster. The same remarks hold for the processes of consonant mutation and dissimilation in the examples in (3).

- (4a) [le-leci] 'stork-NEUT.NOM.SG.'  
 (4b) [ku-kula] 'soft roof-FEM.NOM.SG.'

The process of reduplication is not directly relevant to this study. However, what is important is that copy of the simplex consonants [l] and [k] are observed in (4a) and (4b), respectively. The same reduplicative pattern is frequently attested when the strings [ts] or [dz] appear in word-initial position, as exemplified in (5a) and (5b), respectively.

- (5a) [tsatsara] 'comb-FEM.NOM.S.'  
 (5b) [tsitsiði] 'stark naked-ADV.'

The assumption that this pattern occurs only with singleton onsets would safely lead to the conclusion that [ts] and [dz] are single segments. However, there are some counterexamples of words beginning with 'true' clusters but still form reduplicative-like words. These are illustrated in (6). By 'true' clusters we refer to tautosyllabic consonant sequences, which are recognized across-the-board as clusters by native speakers of Greek, for instance, CL sequences. The data in (4-6) constitute onomatopoeic words, which cannot be considered as representative words of the Greek lexicon. As a result, such data do not provide a strong argument supporting the monopositional nature of affricates.

- (6a) [krikri] 'wild goat from Crete-NEUT.NOM.SG.'  
 (6b) [frufru] 'swish of a dress-NEUT.NOM.SG.'  
 (6c) [psipsina] 'pussy-cat-FEM.NOM.SG.'

### 2.3 Stem alternation

Another frequently cited argument in favor of the monopositional hypothesis stems from -t stems' alternations in environments where -s follows the -t stem. Representative examples come from the formation of the perfective verbal stem (Pagoni 1994, see also Malikouti-Drachman 2000), as shown in (7).

- (7a) θeto → θeso 'put-1SG.PRES.'  
 (7b) prato → prakso 'do-1SG.PRES.'  
 (7c) roto → rotiso 'ask-1SG.PRES.'

The perfective stem is formed by adding [s] to the imperfective stem. In the case of stems ending in [t], the expected outcome, [ts], is avoided either by deletion of the stem-final [t] (7a), or consonant mutation (7b), or insertion of the vowel [i] (7c). According to Pagoni (1994), the reason for the activation of these repair strategies is that the occurrence of a morphological boundary splitting up affricates is not allowed. It is argued that in the same derivational context -p and -k stems remain unaltered, as demonstrated in (8). In (8a) and (8b), the expected output clusters [ps] and [ks], respectively, are realized faithfully.

- (8a) trepo → trepso 'change-1SG.PRES.'  
 (8b) bleko → blekso 'involve-1SG.PRES.'

However, some  $-p$  stems demonstrate the same stem alternations as the  $-t$  stems do. This is exemplified in both cases in (9) in which the vowel [i] is inserted. In addition, coronal stems display similar processes. This is exhibited in (10).

(9a)	zupo	→	zupiso	‘squeeze-1SG.PRES.’
(9b)	ayapo	→	ayapiso	‘love-1SG.PRES.’
(10a)	δrosizo	→	δrosiso	‘refresh-1SG.PRES.’
(10b)	ftano	→	ftaso	‘reach-1SG.PRES.’
(10c)	parkaro	→	parkaro	‘park-1SG.PRES.’

What is common in the above examples is that the output string [cor] + [s] is avoided either by deletion of the stem final consonant (10a, 10b) or by deletion of the affix [s] (10c). For that reason, these data support a strong co-occurrence constraint disallowing the emergence of two adjacent coronals. The exact nature of this constraint is not of direct interest here and further details will remain open for future study. In fact, stem alternations do not refer to affricates only but also clusters such as [ps]. For that reason, these processes do not display different phonotactics of affricates in comparison to clusters.

#### 2.4 Differences with clusters

Affricates and obstruent + /s/ clusters like [ps] and [ks] are differentiated when they occur in word initial position at both the phonological and phonetic level. More specifically, at the phonetic level, when the strident is member of the affricate it has a relatively shorter duration than when it occurs in an obstruent + /s/ cluster (Φουράκης et al. 2005). This could be an indication of the monopositionality of affricates, though the shorter tongue movement needed for their articulation cannot be excluded as an alternative explanation of this shorter duration. In any case, the above argument points to a phonetic difference between affricates and other obstruent + /s/ clusters.<sup>3</sup> At the phonological level, word-initial voiceless [ts] contrasts with voiced [dz]. This is shown in (11).

(11a)	[tsai] 'tea-NEUT.NOM.SG.'	↔	[dzaba] 'for free-ADV.'
(11b)	[tsoylanos] 'bastard-MASC.NOM.SG.'	↔	[dzoyos] 'tolerance of fit-MASC.NOM.SG.'

On the contrary, the voiced counterparts of the strings [ps] and [ks], i.e. [bz] and [gz], are not allowed to occur in word-initial position.<sup>4</sup> This is a second indication of the phonological differences between affricates and other obstruent + /s/ clusters.

#### 2.5 Differences with single segments

Affricates [ts] and [dz] impose more restrictions on the formation of consonantal clusters compared to simplex [t] and [s]. First, simplex [s] can be combined with all obstruents in tautosyllabic clusters, like [sp], [sk] and [st]. Clusters consisting of an affricate + obstruent like \*[tsp], \*[tsk], \*[tst] are ill formed. Note that simplex [t] cannot

<sup>3</sup> The same phonetic properties have been observed in data in which word-final [t] of the preceding word resyllabifies with the following word initial [s] in sequences like [sut su] 'your shot' (Tserdanelis 2004). However, the latter observation does not provide any evidence with respect to the phonological representation of affricates.

<sup>4</sup> However, when a clitic precedes voiced [gz] and [bz] are possible to emerge, e.g. [ðe gzero], [to bzino].

be combined with another obstruent: \*[tp] and \*[tk] are not allowed. Second, simplex [t] can form tautosyllabic consonantal clusters with most sonorants like [tr], [tn] and [tm].<sup>5</sup> Affricates do not share these properties as can be concluded from the illicit non-existing clusters \*[tsl], \*[tsr], \*[tsm] and \*[tsn]. It should be noted that similar restrictions are observed with respect to simplex [s]; \*[sr], \*[sl] and \*[sn] are not allowed.<sup>6</sup>

We can conclude that affricates add up the phonotactic restrictions of both simplex [t] and [s] and differ, in this respect, from simplex segments. This observation, however, does not automatically lead to the conclusion that affricates should be analyzed as two independent segments as has been suggested previously in the literature (Joseph & Philippaki-Warbuton 1987; Pagoni 1994).

## 2.6 Boundaries

The previous observations indicate that there is at least some degree of unity between both members of the affricates (Pagoni 1994). What is common in these observations is that no linguistic boundary may intervene between both affricate members [t] and [s]. First, affricates are never the result of morphological processes like inflection or compounding. Consequently, no morphological boundary can intervene between the members of the affricates [ts] and [dz]. On the contrary, clusters [ps] and [ks] frequently arise as the product of inflection or other word-formation processes. This is exhibited in the examples in (12). In the data in (12a) and (12b), the formation of the perfective stem by adding the affix –s- to the imperfective stem creates the clusters [ps] and [ks]. In the data in (12c – e), nouns are formed by adding the suffix –si or –simo to a verbal stem. The result is the emergence of clusters [ps] or [ks] both members of which are split up by a morphological boundary.

- |       |           |                                     |
|-------|-----------|-------------------------------------|
| (12a) | e-klap-sa | 'cry-1SG.PERF' (cf. kle-o)          |
| (12b) | alak-sa.  | 'change-1SG.PERF.' (cf. alaz-o)     |
| (12c) | kop-si    | 'blade-FEM.NOM.SG..' (cf. kov-o)    |
| (12d) | lek-si    | 'word-FEM.NOM.SG.' (cf. ley-o)      |
| (12e) | γrap-simo | 'writing-NEUT.NOM.SG.' (cf. γraf-o) |

A second indication of the unity of affricates is provided by the fact that no syllabic boundary can intervene between both elements, as displayed in (13) below.

- |       |            |             |                        |
|-------|------------|-------------|------------------------|
| (13a) | [sal.tsa]  | *[salt.sa]  | 'sauce-FEM.NOM.SG.'    |
| (13b) | [sker.tso] | *[skert.so] | 'scherzo-NEUT.NOM.SG.' |

In Greek, branching codas are not allowed (Pagoni 1994).<sup>7</sup> This phonotactic restriction disallows syllabifications like \*[salt.sa] and \*[skert.so]. As a result, affricates can only be syllabified as tautosyllabic onsets. In summary, affricates [ts] and [dz] are unbreakable units at a morphological and a phonological level.

<sup>5</sup> \*[tl] is considered to be ill-formed (Kappa 1995).

<sup>6</sup> Only when they are the result of compounding do /st/, /sl/, and /sn/ occur across morpheme boundaries, e.g. [isreo], [proslamvano]. Note that in the same morphological context other clusters emerge that do not occur elsewhere, e.g. [ekp̄tosi], [ekf̄ero], [isp̄noi].

<sup>7</sup> Branching codas appear in word-final position in some loanwords such as [tanks] 'tank', [sorts] 'short'.

### 3. Preliminary conclusions

The discussion of the phonotactic constraints of Greek leads to the following preliminary conclusions. First, the historical origin of [ts] and [dz] as well as reduplicative-like words and stem alternations do not provide any valid arguments in favor of the monopositionality or bipositionality of the affricates. Second, affricates differ phonetically and phonologically from the other obstruent + [s] clusters, [ps] and [ks]. In addition, affricates differ phonotactically from simplex segments [t] and [s]. Finally, affricates exhibit some degree of unity compared to other /s/ clusters. Consequently, /t/ and /s/ appear, first, as simplex segments, second, as members of the affricates [ts] and [dz] and, third, in consonant clusters including [ps] and [ks].

### 4. Goals of the present study

The main goal of the present study is to investigate the behavior of Greek affricates – /ts/, /dz/- as opposed to other clusters consisting of /s/ + obstruent, and obstruent + /s/, like /sp/ and /ps/, respectively. A related goal is to discuss the validity of the analyses presented above and to test the extent to which they can account for the Greek data.

#### 4.1 Working Hypotheses

The hypotheses underlying our study consist in the following. First, we assume that affricates are more coherent compared to /s/ + obstruent and obstruent + /s/ clusters perception- and production-wise. This claim lies on our theoretical proposal, namely that /s/ cluster coherence is due to the combination of specific factors, first, the position of each cluster member, second the featural synthesis of the C cluster member regarding *both* place *and* manner of articulation and, third, the satisfaction of the Sonority Scale (hereafter SS). Given the above, our second hypothesis is that obstruent + /s/ clusters are more coherent compared to /s/ + obstruent ones perception- and production-wise. Finally, cluster coherence is attributed to the phonological representation of clusters (see also Tzakosta (this volume); Tzakosta & Karra 2007).

### 5. The experimental task

In order to test the validity of the above working hypotheses and evaluate the linguistic mechanisms activated in the perception and the production of the clusters in question, we designed an experimental task which took the shape of a questionnaire. 20 adults, native speakers of Greek (age range: 20-29 years) participated in the experiment. Subjects were asked to break up consonantal strings in 75 existing Greek words by means of inserting a random vowel wherever they considered it convenient. For example, we expect subjects who perceive consonant sequences as clear clusters to break them up as in (14a). Conversely, if subjects do not consider consonantal sequences they are exposed to to be true clusters, they are not expected to break them up, as seen in (14b).

(14a) /proí/ → [po.ro.í]

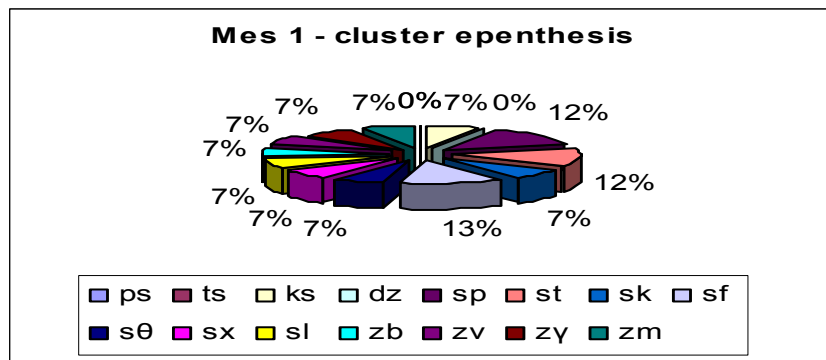
(14b) /proí/ → [pro.í]

### 6. Results and discussion

Overall, the data demonstrated a preference for the preservation of affricates over obstruent + /s/ over /s/ + obstruent clusters. In other words, affricates tend to remain intact, obstruent + /s/ exhibit relative coherence while /s/ + obstruent clusters display the lowest degree of faithful preservation. The subjects showed a strong tendency to break up ‘true’ clusters, i.e. consonant sequences, which they recognized or perceived as

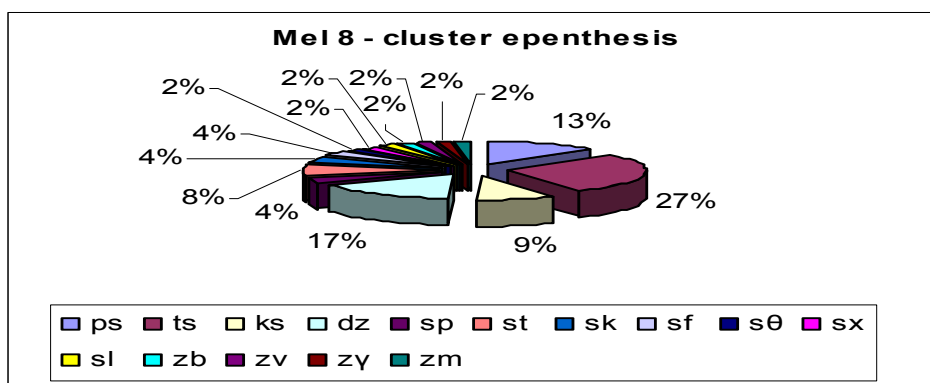
clusters. In graphs 1 and 2 we provide some statistical evidence in favor of the above claims. Mes 1 and Mel 8 are the subjects who display extreme distributions in favor of and against our initial hypotheses. More specifically, graph 1 presents the rates of cluster epenthesis for Mes 1 who is the subject showing absolute preservation of affricates (100%). Mes 1 displays relative coherence of obstruent + /s/ and /s/ + obstruent clusters. Representatively, /st/ and /st/ exhibit a 12% and /sθ/ a 13% rate of epenthesis, whereas /ps/ and /ks/ display a rate of 0% and 7% rate, respectively. Therefore, Mes 1 supports the preservation hierarchy affricates >> obstruent + /s/ >> /s/ + obstruent sequences.

Graph 1 – Mes 1 cluster epenthesis



Mel 8, on the other hand, displays the opposite behavior. More specifically, affricates exhibit the highest degree of decomposition compared to all other /s/ clusters regarding all tested subjects. In the data of Mel 8, affricates /ts/ and /dz/ exhibit a 27% and 17% rate of decomposition, respectively. In addition, /ks/ and /sk/, representatively, demonstrate a 9% and 4 % rate of epenthesis, respectively. It is important to note that, inevitably, affricates are extensively prone to epenthesis because they also constitute the main bulk of the tested items.

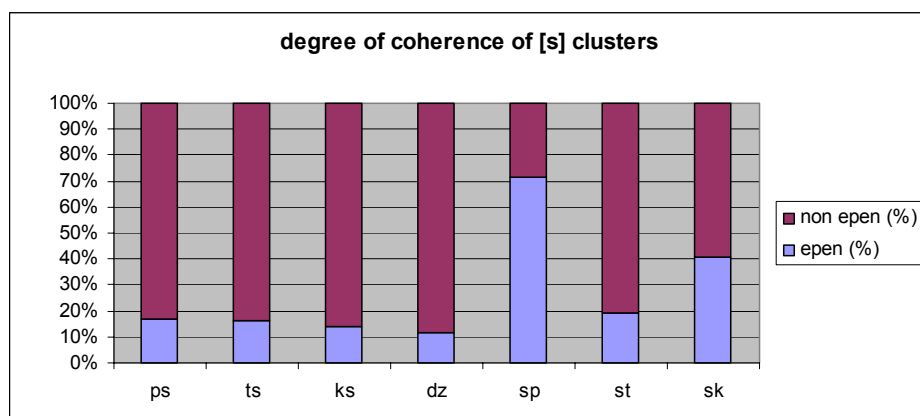
Graph 2 – Mel 8 cluster epenthesis



Graph 3 illustrates the total rates of epenthesis in representative /s/ clusters selected on the basis of their frequency of occurrence in the test. Interestingly, /ps/ and /ts/ exhibit almost the same high rate of faithful preservation, even though /ps/ is a cluster whereas /ts/ is an affricate. This does not go against our claim that affricates exhibit a higher degree of coherence compared to obstruent + /s/ clusters. Especially in the case of /ts/ vs. /ps/ - /ks/, we assume that the historical orthography of Greek influences native

speakers' perception. More specifically, /ps/ and /ks/ represented orthographically as [ψ] and [ξ], respectively, are easy to be perceived as single segments. This is further supported by the fact that other obstruent + /s/ clusters undergo a higher degree of decomposition as can be seen in graphs 1 and 2, for Mes 1 and Mel 8. /sp/, /st/ and /sk/, on the other hand, exhibit the highest rates of decomposition. This underlines the fact that /s/ + obstruent clusters are prone to epenthesis because of the extrametrical status of /s/ in these sequences.

Graph 3 - total



What is also interesting in graphs 1-3 is that /s/ clusters illustrate variable rates of decomposition or faithful preservation depending on additional factors. More specifically, intra-variability of obstruent + /s/ and /s/ + obstruent clusters is attested. We assume that this is attributed to two basic factors; first, the identity of the members of the tested consonantal sequences with respect to place of articulation and, second, the satisfaction of the scale of consonantal strength (Lass 1984). In other words, the members of an affricate share the same place of articulation, i.e. they are both coronal, but they also satisfy the scale of consonantal strength since the initial segment is a stop and the second is a fricative. As a result, affricates exhibit the highest degree of phonological coherence. In addition, obstruent + /s/ clusters exhibit a relative degree of decomposition due to the fact that they violate the first factor, namely their members do not share the same place of articulation and they are, consequently, phonologically less coherent. Finally, /s/ + obstruent clusters undergo the highest degree of decomposition because they violate both criteria, namely they do not share the same place of articulation and violate sonority given that the fricative precedes the stop segment. Therefore, /s/ + obstruent clusters are the, phonologically, least coherent clusters. Therefore, we claim that distinct cluster types are perceived differently because they have different phonological representations mirroring phonological coherence. These representations are given in figures 3-5.



Fig. 3  
Affricates

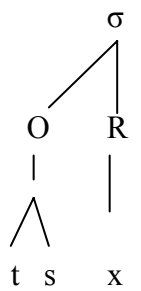
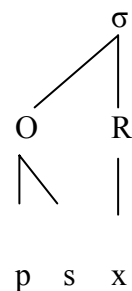


Fig. 4  
SC clusters



Fig. 5  
CS clusters



## 7. Conclusions and future research

Our study aimed at assessing, first, the extent to which /s/ clusters differ from CL clusters, and, second, to investigate the subtle differences in the representation of /s/ clusters including affricates. For this reason, we designed a perception experiment in which 20 adults native speakers of Greek were asked to break up consonant sequences which they recognized as clusters.

The results revealed that affricate members tend to not be broken up, while obstruent +/s/ sequences exhibit a higher degree of coherence compared to /s/ + obstruent ones. The latter display the higher extent of decomposition. Our theoretical interpretation of the results just discussed is that native speakers of Greek perceive affricates as complex segments, while they recognized /s/ as an extrametrical element in sC clusters and Cs clusters as having binary onsets.

A related assumption we make is that cluster complexity is determined, first, by the degree of identity of place of articulation of the cluster members and, second, by the satisfaction of the scale of consonantal strength. To be more specific, affricates tend to not be broken up because their members are identical with respect to place of articulation as well satisfy sonority, i.e. the /t/, the initial segment, is less sonorous than /s/. Based on the above experimental results we suggest that perception and, consequently, production are circumscribed by phonological representations.

Our future research goals related to the present study are, first, to investigate the degree to which word position and stress influence the preservation or reduction of sC and Cs clusters and affricates, second, to explore the exact difference in the representations of affricates and Cs clusters and, finally, to examine phonological coherence of all cluster types.

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