# /s/ clusters in child speech: New evidence from Greek

**Marina Tzakosta**

*University of Crete*
*martzak@edc.uoc.gr*

**Abstract**
In this paper we challenge the ideas promoted by various cross-linguistic theoretical as well as experimental studies regarding the role of /s/ in consonant cluster formation. Most studies opt for markedness and extrametricality accounts which label the marked nature of /s/; this marked nature results in /s/ being deleted in child speech. However, the developmental data discussed here demonstrate different developmental paths in which /s/ appears massively in child Greek in all cluster types and all word positions. Such data cannot be accounted for in terms of markedness or extrametricality. Rather, they are analyzed by means of the *Three Scales Model* (TSM) which assesses cluster formation in terms of three distinct scales. Under the TSM clusters are determined by gradual perfection/ acceptability.

**Keywords:** /s/ clusters, cluster formation, cluster perfection, cluster acceptability, Three Scales Model

## 1. Introduction

/s/ has provoked an ongoing discussion regarding its status in consonantal sequences. There are two major analyses of /s/. On the one hand, /s/ is said to be an appendix (or an adjunct or extrametrical) in SC[1] sequences (cf. Drachman 1989, for adult Greek; Giegerich 1992, for theoretical analyses, see also Barlow 1997, 2001; Gierut 1999, for SLI data; Fikkert 1994, for monolingual child Dutch). On the other hand, SC clusters are seen as complex segments with a representation equivalent to affricates (cf. Fudge 1969; Selkirk 1984).[2] What is predicted by both accounts is that /s/ is expected to undergo deletion in child speech.

On the other hand, other cross-linguistic child language studies have shown that all types of consonant clusters are prone to various simplification strategies during language development. The most salient of these strategies are, first, deletion of the most marked segment among cluster members (1a), second, contiguity (1b), i.e. the

[1] SC stands for clusters in which /s/ is the first member of two-member clusters while CS stands for clusters in which /s/ is the second member of two-member clusters. CL represents [obstruent + liquid] clusters, CC [obstruent + obstruent] clusters and CN [obstruent + nasal] clusters.
[2] For a detailed discussion of these models see Tzakosta (2009), Tzakosta & Vis (2009a, b, c).

retention of the cluster member which is closer to the vocalic nucleus regardless of its degree of markedness, third, fusion (1c), i.e. the production of a segment which is the fused product of the cluster members, fourth, positional faithfulness (1d), mainly favoring word-initial segments, and, five, vowel epenthesis (1e) (cf. Barlow 1997, 2001; Gierut 1999; Fikkert 1994; Kirk & Demuth 2005).

(1a) /**dr**am/ → [**d**am] 'drum' (English, Gnanadesikan 2004)

(1b) /**bl**ad/ → [**l**ɑt] 'leaf' (Dutch, van der Pas 2004)

(1c) /**fr**og/ → [**b**o.gi] 'frog' (English, Barlow 1997)

(1d) /**fr**i.γa.nú.la/ → [**f**ú.la] 'cracker-DIM.' (Greek, D: 2;03.07)

(1e) /**xt**i.pá.i/ → [γæ.**t**i.bá.i] 'hurt-3SG. PRES.' (Greek, Me: 2;00.26)

More specifically for Greek, Tzakosta (2009) and Tzakosta & Vis (2009a, b, c) have investigated the repair strategies applied in different cluster types as well as the frequency rates of the former. Tzakosta (2009) and Tzakosta & Vis (2009 a, b, c) have reported that CL clusters undergo various types of repair mechanisms, such as reduction, fusion, epenthesis, while /s/ clusters massively undergo reduction of their marked segment based on markedness principles and argue that /s/ is deleted because /s/ sequences violate the Sonority Scale (hereafter SS) which is depicted in schema 1.

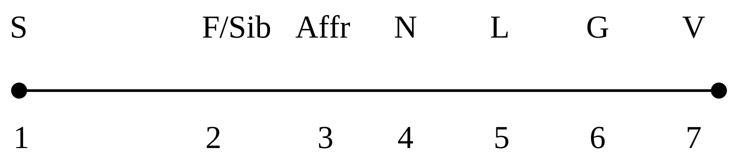



*Figure 1. The classical sonority scale*

According to the SS, only the rightward selection of cluster members results in better-formed consonant sequences whereas leftward selection of segments results in non well-formed clusters. Therefore, sequences consisting of [stop + fricative] segments, like [ps], are acceptable, whereas sequences consisting of [fricative + stop], like [sp], are not well-formed. Cluster well-formedness is also evaluated on the basis of Sonority Distance (hereafter SD) according to which the bigger the distance among cluster members is on the SS, the better-formed the cluster is. Therefore, /pl/ is better than /fl/ because the SD for /pl/ is 4 while SD for /fl/ is 3.

In (2) we provide representative examples of SC clusters drawn from Tzakosta (2009) and Tzakosta & Vis (2009a, c). In these data, /s/ is deleted or fused, as shown in the examples in ((2a)-(2d)) and ((2e)-(2f)), respectively. In ((2g)-(2h)) /s/ clusters undergo vowel epenthesis.

(2a) /δó.**st**o/ → [δó.**t**o] ‘give it-IMP.2’ (B.T. 1;11.07)

(2b) /**sc**í.los/ → [**c**í.lo] ‘dog-SG.MASC.’ (F. 2;00. 27)

(2c) /**sp**i.tá.ci/ → [**p**i.ta.ci] ‘house-SG.NEUT.DIM.’ (Kon: 1.11)

(2d) /**sx**o.lí.o/ → [**x**o.lí.o] ‘school-SG.NEUT.’ (Ma: 2;00.07)

(2e) /**sk**u.fá.ci/ → [**t**e.fá.ci] ‘hat-SG.NEUT. DIM.’ (B.M.: 2;07)

(2f) /**sc**i.lá.ci/ → [**t**i.lá.ti] ‘dog-SG.NEUT.DIM.’ (I.: 2;04.03)

(2g) /**st**é.la/ → [**te**.**θ**é.la] ‘Stella-proper name’ (B.M.: 2;05.21)

(2h) /**br**o.**st**á/ → [bo.**θ**∂.**t**á] ‘front-ADV.’ (Kon. 2;00.01)

The findings for CS clusters are relevant; the data in (3) come from the same pool of data in which CS sequences are repaired by means of, first, /s/ deletion due to the preservation of the unmarked member of the cluster ((3a)-(3c)), second, fusion ((3d)-(3f)) and, third, vowel epenthesis (3g).

(3a) /**ps**é.ma/ → [**p**é.ma] ‘lie-SG. NEUT.’ (B.M. 1;11.01)

(3b) /**ks**í.lo/ → [**c**í.lo] ‘stick-SG.NEUT.’ (I.: 2;05.24)

(3c) /ftjá.**ks**o/ → [**ft**á.**k**o] ‘repair-1SG. FUT.’ (Ma.: 2;07.06)

(3d) /pé.**ks**o/ → [pé.**t**o] ‘play-1SG.SUBJ.’ (B.M.: 1;11.18)

(3e) /**ps**i.lá/ → [**f**i.lá] ‘high-ADV.’ (D.: 2;02)

(3f) /pe.tá.**ks**o/ → [pe.tá.**t**o] ‘throw-1SG.SUBJ.’ (F.: 2;01.18)

(3g) /**ks**é.ro/ → [**k**∂.**δ**é.o] ‘know-ISG.IND.’(D.: 2;04.17)

Affricates in (4) exhibit equivalent patterns; they undergo simplification through deletion or fusion. Such data provide support to the assumption that affricates are consonant clusters which are either reduced to the unmarked segment of the cluster ((4a)-(4e)) or fused ((4f), (4g)). However, the fact that affricates do not undergo epenthesis like other /s/ clusters led Tzakosta & Vis (2009a, b, c) to the assumption that affricates are complex segments. Therefore the data in (4) provide an ambiguous picture regarding the status of affricates.

(4a) /e.le.ní.**ts**a/ → [ní.**t**a] ‘proper name’ (B.M.: 1;09.22, 1;10.18)

(4b) /ku.kú.**ts**i/ → [kú.**t**i] ‘core-SG.NEUT.’ (.T.: 1;10)

(4c) /ka.ró.**ts**i/ → [tetu.ró.**t**i] ‘pushchair-SG.NEUT.’ (D.: 2;01)

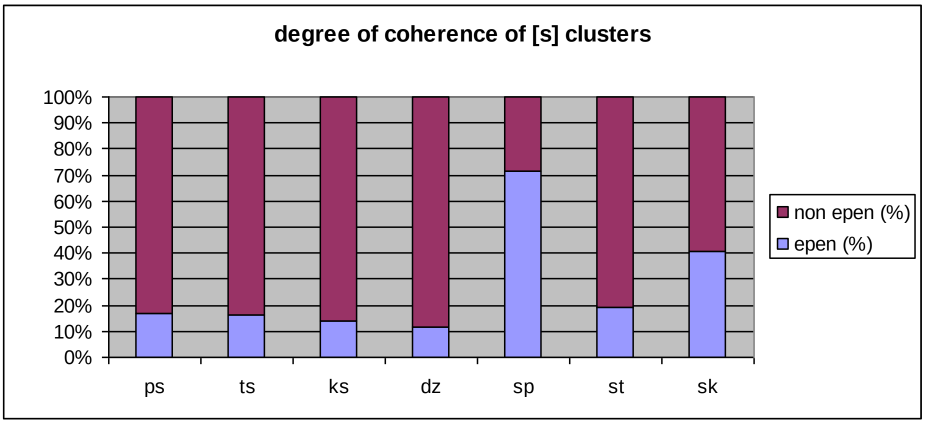
(4d) /mu.**dz**ú.ra/ → [mu.**d**ú.ra] ‘stain-SG.FEM.’ (I.: 3;01.03)

(4e) /ko.pe.lí.**ts**a/ → [ko.pe.lí.**t**a] 'lady-DIM.' (Ma.: 2;07.06)

(4f) /**ts**i.bá.i/ → [**θ**e.fá.i] 'bite-3SG.PRES.' (.M.: 2;02.05)

(4g) /pe.**ts**é.ta/ → [pe.**θ**é.ta] 'towel-SG.FEM.' (F.: 2;09.05)

The above data underline the fact that /s/ clusters – no matter what the position of /s/ is – are massively repaired by means of various strategies. These facts are supported by additional data which display that during intermediate developmental stages other cluster types, i.e. CL and CC clusters, emerge systematically, while /s/ clusters keep on being simplified (Tzakosta 2009). Based on their off-line experimental findings, Tzakosta & Vis (2009c) provide statistical evidence (graph 1) showing that different /s/ clusters exhibit various repair strategies rates irrespective of whether /s/ is the first or second member of the cluster.




*Graph 1. Degree of coherence of /s/ clusters*

Given the above, Tzakosta (2009) and Tzakosta and Vis (2009a, c) argue that different degrees of variation in cluster production are attributed to different degrees of coherence clusters exhibit with respect to the Sonority Scale (SS) and related factors. More specifically, although CL clusters undergo various types of repair mechanisms (such as reduction, fusion, epenthesis), /s/ clusters massively undergo reduction of their marked segment, because /s/ sequences violate the SS (cf. Goad and Rose 2004, for a different account). Tzakosta & Vis (2009c) claim that different degrees of coherence are attributed to and depicted in different structural representations of /s/ clusters. Representations of affricates, SC and CS clusters are illustrated in figures 2, 3 and 4, respectively.

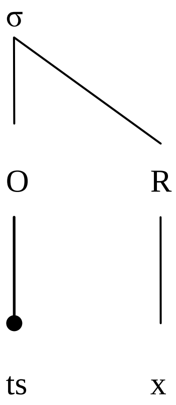



*Figure 2. Affricates*

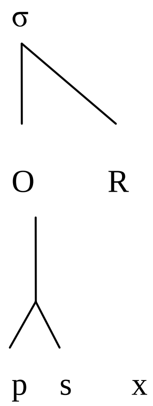



*Figure 3. CS clusters*

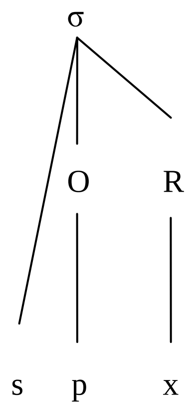



*Figure 4. SC clusters*

## 2. Method and research questions

The present study draws on longitudinal production data from one child (Chr., age range: 1;03-3;00) who acquires Greek as a mother language. The child's data were recorded on a weekly basis and each session lasted between 20-35 minutes. The data were broadly transcribed in the IPA. Except for the recordings, diary notes were kept.

Our research goals are summed up in the examination of, first, the behavior of different /s/ clusters - including affricates - and, second, how /s/ clusters behave in comparison to other cluster types.

## 3. Data

In the discussion that follows, the data are categorized in terms of, first, different cluster types, i.e. SC, CS and affricates and, second, two major data collection periods; the first period is between 1;03-2;0 years and the second period between 2;01-3;0 years of age. These two time periods are marked by different developmental patterns. More specifically, during the first period (1;03-2;0 years), the majority of SC are accurately targeted, while CS clusters and affricates are simplified by means of markedness considerations.[3] Some representative examples are provided in (10) below. It is important to note that, although /s/ sequences tend to be simplified when they are the sole clusters of the word (examples in (10a-c)), they are accurately realized – at least regarding the number of cluster members – when they coexist with other cluster types, like CL clusters (examples in (10d-f)). It is worth mentioning that,

[3] It is only before the age of 1;05 years when /s/ clusters were simplified by means of /s/ reduction. Given that no other cluster types were produced at that time, we are not concerned with data before that age.

when three-member clusters are reduced, it is the liquid and not /s/ that is deleted (10g). Such data are impossible to be analyzed through extrametricality or markedness accounts.

(10a) /**st**á.θis/ → [**θt**á.θə], [**θ**á.θə], [**θ**á.θa], [**t**á.θə] ‘proper name’ (Chr.: 1;05-1;08)

(10b) /**sk**á.se/ → [**k**á.θe] ‘shut up-2SG.IMP.’ (Chr.: 1;08-1;10)

(10c) /**sk**á.les/ → [**k**á.θe] ‘stairs-FEM.PL. ‘

(10d) /**br**o.**st**á/ → [**b**o.**θt**á] ‘in front-ADV.’

(10e) /**xr**i.**st**í.na/ → [ti.**θt**í.na], [θi.**θt**í.na] ‘proper name’ (Chr.: 1;10-2;01)

(10f) /'**kl**i.**st**o/ → ['**c**i.**θt**o] ‘close it-2IMP.’

(10g) /'**spr**o.xno/ → ['**fp**o.xno] ‘push-IND. PRES.’ (Chr.: 2;00)

Though our study is not quantitative in nature, the few data of CS clusters in (11) give some evidence that CS sequences are the least targeted /s/ clusters. The data in (11) further display that /s/ undergoes fusion in CS sequences.

(11a) /é.**ks**i/ → [é.**t**i] ‘six’

(11b) /ma.**ks**i.lá.ri/ → [ma.**θ**i.lá.i] ‘pillow-SG.NEUT.’ (Chr.: 1;08-1;10)

Finally, affricates are either simplified to the least marked segment of the sequence ((12a)-(12c)), or fused ((12d)-(12e))[4] or correctly produced ((12b), (12c)). Such data support analyses which see affricates as clusters.

(12a) /kál.**ts**a/ → [ká.**t**ə] ‘sock-SG.FEM.’ (Chr.: 1;03)

(12b) /ka.ró.**ts**i/ → [kó.**ts**i], [kó.**t**i] ‘pushchair-SG.NEUT.’ (Chr.: 1-04-1;05)

(12c) /**ts**á.i/ → [**t**$^{h}$á.i], [**t**á.i], [**ts**á.i] ‘tea-SG.NEUT.’ (Chr.: 1;05-1;08)

(12d) /kál.**ts**es/ → [ká.**θ**e] ‘socks-FEM.PL.’

(12e) /δen **ks**é.ro/ → [δe**δ**é.o] ‘know-1SG.PRES.IND.’ (Chr.: 1;08-1;10)

The second period of the data classification (2;02-3;0 years) exhibits interesting patterns. In data like that in (13), it is evident that /s/ is not the cluster member which is being deleted.

(13) /á.**spr**o/ → [á.**fp**o] ‘white-SG.NEUT.ADJ.’

[4] In (12e) the fused segment further undergoes voicing and surfaces as /δ/. We attribute this voicing effect to the intervocalic position of the fused segment.

However, an interesting pattern emerges in which CS clusters and affricates are massively substituted for SC sequences. This pattern is attested across-the-board during this developmental phase. All data of CS sequences and affricates are presented in (14) and (15), respectively. Such data further contradict extrametricality or extrasyllabicity analyses since /s/ tends to be an indispensable element of /s/ sequences, preferably in cluster initial positions. The data provide partial support for the claims made by Tzakosta (2009) and Tzakosta & Vis (2009a, c) regarding the internal structural coherence of /s/ clusters which allows the latter to surface (almost) intact. In other words, although CS clusters are considered to be the most coherent consonantal sequences, therefore, the most probable to remain intact in production under the Tzakosta & Vis proposal, the data in (14) and (15) illustrate that CS clusters exhibit various production patterns.

(14a) /po.li.**ks**é.ni/ → [θe.**θ**é.ni], [θe.**θt**é.ni] 'proper name'
(14b) /e.dá.**ks**i/ → [dá.**θt**i] 'ok'
(14c) /korn flé.i**ks**/ → [kón éi**θt**] 'corn flakes'
(14d) /ta.**ks**í.δi/ → [**θt**í.δi] 'trip-SG.NEUT.' (Chr.: 2;02-2;06)
(14e) /na **kr**í.**ps**is/ → [cí.**fp**iθ] 'hide-2SG.SUBJ.'
(14f) /na δu.lé.**ps**o/ → [na δu.lé.**fp**o] 'work-1SG. SUBJ.'
(14g) /θa se δjó.**ks**o/ → [θa θe jó.**θt**o] 'send away-1IND.FUT.'
(14h) /min to a.lá.**ks**is/ → [ni to a.lá.**θt**iθ] 'not change-2IMP.SG.'
(14i) /na to a.ná.**ps**o/ → [na to a.ná.**fp**o] 'light it-1SUBJ.SG.'
(14j) /mí.**ks**a/ → [mí.**θt**a] 'snot-SG.FEM.'
(14k) /a.má.**ks**i/ → [a.má.**θt**i] 'car-SG.NEUT.'
(14l) /'e.**ks**o/ → ['e.**θt**o] 'out-ADV.' (Chr.: 2;07-3;0)
(14m) /ma.**ks**i.lá.ri/ → [ma.**θt**i.lá.i] 'pillow-SG.NEUT.' (Chr.: 2;07-3;0)

(15a) /rí.**ts**a/ → [í.**θt**a] 'proper name'
(15b) /**ts**á.i/ → [**θt**á.i] 'tea-SG.NEUT.'
(15c) /jí.**ts**es/ → [jí.**θt**eθ] 'bless you'
(15d) /ko.rí.**ts**i/ → [ko.í.**θt**i] 'girl-SG.NEUT.'
(15e) /pa.pú.**ts**i/ → [pa.pú.**θt**i] 'shoe-SG.NEUT.'
(15f) /pa.na.jí.**ts**a/ → [í.**θt**a] 'virgin Mary-SG.FEM.DIM.'
(15g) /mu.rí.**ts**a/ → [mu.í.**θt**a] 'face-SG.FEM.DIM.'
(15h) /**ts**ír.ko/ → [**θt**í.ko] 'circus-SG.NEUT.' (Chr.: 2;02-2;06)

(15i) o.δo.dó.vur.**ts**a/ → [vo.vó.vo.**θt**a] 'toothbrush-SG.FEM.' (Chr.: 2;07-3;0)

To summarize, the findings from the data presented in (10) – (15) let us deduce that /s/ clusters – and especially SC sequences - resist reduction. The patterns discussed in (10)-(15) emerge across-the-board during intermediate developmental stages. Given the above, we propose three stages in the development of /s/ clusters:

**Stage 1:** SC clusters and affricates are correctly produced in the majority of the attested cases, though CS clusters are prone to reduction of their more marked segments. All other cluster types are simplified.

**Stage 2:** SC clusters are correctly produced; affricates and CS sequences undergo metathesis. All other cluster types are simplified.

**Stage 3:** /s/ clusters and all other cluster types are correctly produced.

## 4. Discussion

The main problem one has to face when trying to analyze the new data discussed in section 3 in which /s/ is primarily preserved in child productions is that the data are difficult to be accounted for by means of markedness or extrametricality considerations. On the one hand, the direct outcome of the SS is that clusters are mainly evaluated on the basis of the distance among cluster members irrespective of place, manner or voicing considerations. As a result, we cannot make an in depth evaluation of the degree of cluster perfection and cluster well-formedness. To give an example, we accept that **CL** and **CN** clusters, such as /pl/ and /fn/, respectively, are both well-formed clusters in Greek; however, /pl/ is better formed than /fn/, given the bigger sonority distance between /p/ and /l/ compared to /f/ and /n/. The problem arises in clusters with smaller SD. To be more specific, the distance between the members of the clusters /tf/ and /kθ/ is exactly the same, 1, given that the initial segment of both clusters is a stop and the second is a fricative. Therefore, both clusters should be appointed the same degree of cluster well-formedness. Nonetheless, /tf/ is unacceptable in Greek, while /kθ/ is acceptable. Why is /tf/ unacceptable if SD is satisfied? In the same line of argumentation, /s/ clusters violate the SS – especially in cases of [/s/ + stop] sequences - although they are perfectly acceptable in Greek.

Under extrametricality, on the other hand, /s/ should be the reduced cluster member. However, the child language data discussed above showed an inter-play between /s/ clusters. Finally, the account based on structural complexity (Tzakosta & Vis 2009a, b, c) is only partly satisfactory because, if cluster coherence is more crucial than cluster clarity, the cluster representations offered in Tzakosta & Vis (2009a, b, c) do not provide an adequate explanation as to why CS sequences, which are the most coherent consonantal clusters, are prone to variable repair mechanisms in production.

In order to account for these puzzling data, we propose a new theoretical model, the *Three Scales Model* (hereafter TSM) which was initially proposed by Tzakosta (2010, 2011, 2012, 2013) and Tzakosta and Karra (2011), for dialectal data. The TSM evaluates consonant clusters on the basis of the (degree of) satisfaction or violation of three scales, namely the scales of manner of articulation, place of articulation and voicing. The main claim of the present approach is that the SS and SD and structural complexity account are not explanatorily sufficient theoretical tools to account for the systematic emergence of /s/ clusters in Greek varieties given that /s/ clusters are non-theory-predicted clusters. We argue that the scales of manner, place and voicing are involved in cluster formation, well-formedness and, consequently, in the gradual nomination of clusters as perfect, acceptable and non-acceptable.

According to the TSM, the SS should be only one of the dimensions of evaluating consonant clusters' well-formedness. More specifically, all cluster types, among which /s/ clusters, should be evaluated separately with respect to Place of Articulation (hereafter PoA), Manner of articulation (hereafter MoA) and Voicing (hereafter V) in order to assess subtle cluster differentiations. We suggest that clusters are perfect, acceptable and non-acceptable depending on the degree of satisfaction of the scales of place, manner and voicing which are illustrated in figures 5, 6 and 7, respectively.

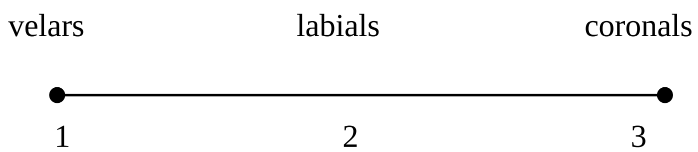



*Figure 5. The PoA scale*


*Figure 6. The MoA scale*

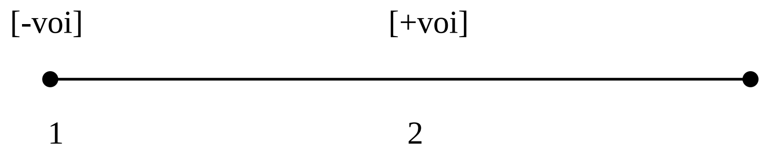



*Figure 7. The V scale*

The idea of the three scales which the TSM is built on is not brand new. Drawing on cross-linguistic data, Morelli (1999) displayed that the classical SS is not adequate to account for cluster well-formedness. The PoA hierarchy has been proposed by Prince & Smolensky (2004), while the importance of voicing for sonority is discussed by Parker (2002). However, it appears to be the first time that the three scales are combined in one model which assesses cluster formation.

The PoA, MoA and V scales are satisfied in a rightward manner just like the SS. Clusters are perfect under one major condition: to minimally satisfy all scales. On the other hand, clusters are acceptable under three conditions: first, if they vacuously satisfy all scales i.e. if SD 0, second, if they violate one of the scales of manner or place and (vacuously) satisfy the other but always (and at least vacuously) satisfy the voicing scale, and, third, if the voicing scale is at least vacuously satisfied but both scales of manner and place are violated. Vacuous satisfaction is characteristic of acceptable cluster but never of perfect clusters[5]. Non-acceptable clusters emerge as long as, first, all scales are violated, and, second, the voicing scale is violated even if the manner and place scales are vacuously satisfied.

However, not all clusters are perfect to the same extent, since cluster perfection is gradient; the bigger the D among cluster members on all scales the better-formed the cluster (Tzakosta 2010, 2011, 2012, 2013). For example, /pl/ and /fl/ are both perfect clusters, but /pl/ is better-formed than /fl/ because the SD is bigger for /pl/ (4) than for /fl/ (3). In sum, we argue that cluster formation is driven by the parallel satisfaction of multiple scales, those of manner, place and voicing in combination to D.[6]

---

[5] Vacuous satisfaction is signaled by '○' in the tables.

[6] Syrika (2010) and Syrika et al. (2011) provide evidence from production tasks conducted on children and adults that *s*-stop clusters and /ts/ almost always reduce to a stop, whereas errors for the stop-*s* clusters /ps/ and /ks/ mainly involve reduction to a fricative. A possible explanation is sought in the sonority-based perceptual salience of the involved elements: *s*-stop clusters are easier for children to produce (esp. in initial positions) because they provide a richer environment for stop place perception than stop-*s* clusters in the same environment. These findings seem to go against the predictions of the sonority scale, which presumes that the stop here should be retained, though not against the TSM according to which cluster formation and cluster well-formedness is a relative notion.

There are two innovative features of the present approach; on the one hand, apart from the fact that the TSM is more flexible regarding the definition of well-formed clusters, it can account for the formation of all cluster types. More specifically, our proposal solves the problem of the status of /s/ in consonant clusters since we do not need to characterize /s/ as extrametrical (Drachman 1989; Giegerich 1992) when it emerges in cluster-initial position or as part of a complex segment (Fudge 1969; Selkirk 1984) when it emerges in cluster-final position. Rather, we evaluate all cluster types on a par. On the other hand, the violation of all scales is an indication that non-acceptable clusters might be heterosyllabic. In other words, the TSM gives new insights regarding the phonotactic constraints and the principles which drive syllabification in Greek (Tzakosta 2013). Moreover, it makes a proposal regarding clusters' internal coherence and other factors which drive cluster acceptability and cluster perfection in different languages or different aspects of the same language (Tzakosta 2010, 2011, 2012, 2013). The TSM is differentiated from the proposal of Tzakosta & Vis (2009a, b, c) in that the TSM is not restricted to the description of consonant clusters representations, rather, it provides a detailed and unified account of consonant clusters' internal coherence as well as gradual perfection and (non-) acceptability. In addition, it makes predictions regarding the perception and production of different cluster types.

Table 1 provides examples of gradual satisfaction of the scales of place, manner and voicing, and, therefore, gradual perfection and/ or acceptability of cluster well-formedness. Asterisks indicate scale violation while ticks indicate scale satisfaction. Therefore, all SC clusters are acceptable, though /sp/, /st/ and /sk/ are worse than /sf/, /sθ/ and /sx/. The former violate two out of three scales, while the latter violate only one scale. On the other hand, all CS clusters and affricates are perfect clusters because they satisfy all scales. However, even some perfect clusters are better-formed than others; for example, /ps/ and /ks/ are better than /fs/, /θs/ or /xs/ because the former preserve a minimal D1 among their cluster members on the manner scale, while the latter vacuously satisfy it. Such comparisons are made regarding all three scales.

Another question that remains to be answered is why perfect clusters like /ps/ are substituted for acceptable /sp/ clusters in child speech. We argue that children opt for different developmental paths in which scale prominence varies. In other words, acceptable clusters may be preferred to perfect ones depending on the quality and the structure of the developmental paths adopted by each child during their language acquisition. For example, the satisfaction of the manner scale may be crucial for some children but it may be on minor importance for other children. As a result, certain children prefer to produce acceptable instead of perfect clusters.

| Clusters/ scales | PoA | MoA | V |
|---|---|---|---|
| /sp/ | * | * | √ |
| /st/ | ○ | * | √ |
| /sk/ | * | * | √ |
| /sf/ | * | √ | √ |
| /sθ/ | ○ | √ | √ |
| /sx/ | * | √ | √ |
| /ps/ | √ | √ | √ |
| /ks/ | √ | √ | √ |
| /fs/ | √ | √ | √ |
| /θs/ | ○ | √ | √ |
| /xs/ | √ | √ | √ |
| /ts/ | ○ | √ | √ |
| /dz/ | ○ | √ | √ |

*Table 1. Satisfaction of the TSM*

The implications of the TSM are developmental and typological. More specifically, cluster gradient well-formedness makes predictions regarding the order of phonological acquisition in Greek and also cross-linguistically. It also provides a unified account of cluster formation in a language and its dialects. The TSM does not constitute an implicational universals account. In other words, the TSM does not imply that if a language has acceptable clusters then it also has perfect clusters; rather, the model provides the tools for defining well-formedness and cluster coherence.

## 5. Conclusions

In this paper we provide new evidence regarding the status of /s/ clusters which contradicts the theoretical accounts proposed till recently. More specifically, although most cross-linguistic studies on the acquisition of L1, including Greek, have reported that /s/ cluster massively undergo reduction of /s/ - no matter whether it is the first or second member of the cluster or whether it is the most marked member of the cluster or not – till late stages of phonological development. However, the data discussed here illustrate that /s/ surfaces in child data no matter what its position in the word is or what its degree of markedness is. This fact opposes theories of markedness, extrametricality or cluster coherence. We have argued that the new data can only be accounted for through the three scales model, a theoretical account initially proposed for dialectal data (Tzakosta 2010, 2011; Tzakosta & Karra 2011), according to which cluster formation is determined by different degrees of well-formedness and is evaluated on the basis of three distinct scales, the scale of manner, of place and voicing. Clusters may be gradually well-formed, namely they can be perfect, acceptable and/ or non-acceptable depending on the satisfaction of these three scales. The voicing scale is essentially satisfied for a cluster to be perfect or acceptable. This implies that the scales of manner and/ or place may be violated though clusters are still acceptable.

The contribuion of the present proposal is twofold; on the one hand, the three scales model is more flexible regarding the definition of well-formed tautosyllabic clusters, therefore, there is no need for the recruitment of additional accounts in cases in which attested clusters are theoretically unpredictable. Since the voicing scale is essentially satisfied in well-formed clusters, its violation by other clusters signals that the latter might be heterosyllabic sequences, though more data is needed on that specific issue.

The TSM solves the problem of the status of /s/ in consonant clusters since we do not need to characterize /s/ as extrametrical (Drachman 1989; Giegerich 1992) when it emerges in cluster-initial position or as part of a complex segment (Fudge 1969; Selkirk 1984) when it emerges in cluster –medial or -final position. Rather, we evaluate all cluster types on a par. Finally, the model makes predictions regarding the order of acquisition of different cluster types.

## References

Barlow, J. 1997. *A constraint-based account of syllable onsets: Evidence from developing systems*. Ph.D. Dissertation, Indiana University.

Barlow, J. 2001. The structure of /s/ sequences: Evidence from a disordered system. *Journal of Child Language* 28: 291-324.

Drachman, G. 1989. A remark on Greek clusters. In J. Mascaro & M. Nespor (eds), *Grammar in progress*. Glow essays for Henk v. Riemsdijk. Dordrecht: Foris.

Fikkert, P. 1994. *On the acquisition of prosodic structure*. Ph.D. dissertation, HIL Dissertation Series 6, Leiden University. The Hague: Holland Academic Graphics.

Fudge, E. 1969. Syllables. *Journal of Linguistics* 5: 253-286.

Giegerich, H.J. 1992. *English phonology: An introduction*. Cambridge: C.U.P.

Gierut, J. 1999. Syllable onsets: Clusters and adjuncts in acquisition. *Journal of Speech, Language and Hearing Research* 42: 708-726.

Gnanadesikan, A. 2004. Markedness and faithfulness constraints in child phonology. In R. Kager, J. Pater & W. Zonneveld (eds), *Constraints in phonological acquisition*. Cambridge: C.U.P., 73-108.

Goad, H. & Y. Rose. 2004. Input elaboration, head faithfulness and evidence for representation on the acquisition of left-edge clusters in West Germanic. In R. Kager, J.V. Pater & W. Zonneveld (eds), *Constraints on phonological acquisition*. Cambridge: C.U.P, 109-157.

Kirk, C. & K. Demuth. 2005. Asymmetries in the acquisition of word-initial and word-final consonant clusters. *Journal of Child Language* 32: 709-734.

Morelli, F. 1999. *The phonotactics and phonology of consonant clusters in Optimality Theory*. Ph.D. Dissertation, University of Maryland.

Parker, S.G. 2002. *Quantifying the sonority hierarchy*. Ph.D. Dissertation, University of Massachussets Amherst.

van der Pas, B. 2004. Contiguity in phonological acquisition. In J Kampen van and Baauw (eds), *Proceedings of Generative approaches to language acquisition (GALA) 2003.* vol. 2. LOT Occasional Series 3. Netherlands: LOT, Netherlands Graduate School of Linguistics, 353-364.

Prince, A. & P. Smolensky. 2004. *Optimality theory: Constraint interaction in Generative Grammar.* Oxford: Blackwell.

Selkirk, E. 1984. *Phonology and syntax: The relation between sound and structure*. Cambridge, Massachusetts/ London, England: The MIT Press.

Syrika, A. 2010. *Consonant cluster acquisition in Greek: Evidence from transcription, perception, and psychoacoustics.* Ph.D. Dissertation, Department of Communicative Disorders, University of Wisconsin, Madison.

Syrika, A., K. Nicolaidis, J. Edwards & M.E. Beckman. 2011. Acquisition of initial /s/-stop and stop-/s/ sequences in Greek. *Language and Speech* 54.3: 361-386.

Tzakosta, M. 2009. Asymmetries in /s/ cluster production and their implications for language learning and language teaching. In A. Tsangalidis (ed.), *Selected Papers from the 18$^{th}$ International Symposium of Theoretical and Applied Linguistics (18 ISTAL).* School of English, Aristotle University of Thessaloniki. Thessaloniki: Monochromia, 365-373.

Tzakosta, M. 2010. 'The importance of being voiced:' Cluster formation in dialectal variants of Greek. In A. Ralli, B. Joseph, M. Janse & A. Karasimos (eds), *E-proceedings of the 4$^{th}$ International Conference of Modern Greek Dialects and Linguistic Theory*. University of Patras, 213-223. Retrieved March 2014 from http://www.philology.upatras.gr/LMGD/el/index.html

Tzakosta, M. 2011. Consonantal interactions in dialectal variants of Greek: A typological approach of three-member consonant clusters. In C. Basea-Bezadakou, I. Manolessou, G. Afroudakis, G. Katsouda & S. Beis (eds), *Modern Greek Dialectology 6*. Athens: Academy of Athens – Research Center for Modern Greek Dialects, 463-483.

Tzakosta, M. 2012. Place and manner interactions in Greek cluster phonotactics. In P. Hoole, L. Bombien, C. Mooshammer, M. Pouplier & B. Kuhnert (eds), *Consonant Clusters and Structural Complexity, Volume 26. Interface Explorations Series.* Berlin/Boston: Mouton de Gruyter, 93-118.

Tzakosta, M. 2013. The special role of /s/ in cluster formation. *Online Proceedings of the 5$^{th}$ International Conference of Modern Greek Dialects and Linguistic Theory (MGDLT 5)*. Ghent: Koninklijke Academie voor Nederlandse Taal en Letterkunde, 487-498. Retrieved January 2014 from http://lmgd.philology.upatras.gr/en/research/products.html

Tzakosta, M. & A. Karra. 2011. A typological and comparative account of CL and CC clusters in Greek dialects. In M. Janse, B. Joseph, P. Pavlou, A. Ralli & S. Armosti (eds), *Studies in Modern Greek Dialects and Linguistic Theory I*. Nicosia: Kykkos Cultural Research Centre, 95-105.

Tzakosta, M. & J. Vis. 2009a. Asymmetries of consonant sequences in perception and production: affricates vs. /s/ clusters. In A. Tsangalidis (ed.), *Selected Papers from the 18th International Symposium of Theoretical and Applied Linguistics (18 ISTAL).* School of English, Aristotle University of Thessaloniki. Thessaloniki: Monochromia, 375-384.

Tzakosta, M. & J. Vis. 2009b. Perception and production asymmetries in Greek: Evidence from the phonological representation of CC clusters in child and adult speech. *Proceedings of the 29th Annual Meeting of Greek Linguistics.* Thessaloniki: Faculty of Philosophy, Aristotle University of Thessaloniki. Institute of Modern Greek Studies, 553-565.

Tzakosta, M. & J. Vis. 2009c. Phonological representations of consonant sequences: The case of affricates vs. 'true' clusters. In G.K. Giannakis, M. Baltazani, G.I. Xydopoulos & A. Tsaggalidis (eds), *E-proceedings of the 8th International Conference of Greek Linguistics (8ICGL).* Department of Philology: University of Ioannina, 558-573. Retrieved January 2014 from http://www.linguist-uoi.gr/cd_web/arxiki_en.htm