

The structure of initial /s/-clusters: evidence from L1 and L2 acquisition *

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Abstract

This paper examines the structural representation of word-initial /s/-clusters in English. Currently, there stands to be a vast amount of literature on the acquisition of /s/-clusters both in First Language (L1) acquisition and Second Language (L2) acquisition. Hereafter, the goal of this paper is to unify the main findings of L1 and L2 acquisition. This in return will lead to a discussion on the structural representation of /s/-clusters, in where we argue that initial /s/-clusters are complex segments. The L2 data is drawn primarily from Turkish learners of English, and the implications regarding structural representations and variation will be addressed.

1. Introduction

Research findings on normal L1 development- as well those who have phonological deficit- has shown that children experience difficulty in producing consonant clusters. The main concern of studies of this kind has been to document the order of emergence and common substitution patterns of clusters in acquisition. However, acquisition research has shown that children satisfy the same output target in diverse ways, and they also differ in terms of which individual cluster or singleton is acquired first, and which is acquired last.

Rule-based (or derivational) phonology assumes that in the initial stage children's grammar is composed of rules that simplify the adult or target form to the unmarked form (e.g. Stampe 1979). It also predicts that the cluster simplification rules become optional and then they are eventually lost once the correct forms have been acquired (e.g. Kiparsky and Menn 1977). Rule-

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based phonology does not however account for early child phonology which involves more rules than the target adult form. This high variability, however, can be captured in a nonderivational, constraint-based theoretical framework, known as Optimality Theory (hereafter OT) (McCarthy and Prince 1995; Prince and Smolensky 1993). OT assumes that grammars consist of ranked constraints, rather than ordered rules, and the constraints, which require the child's production, to be unmarked in structure is never lost. Instead, the constraints are demoted in the grammar but still potentially remain active.

The OT syllable structure constraints relevant to the present study are of two types: (1) Faithfulness constraints, which require that surface or output forms resemble underlying or input forms (Faithfulness constraints therefore prohibit repair strategies such as deletion, insertion, and feature change), and (2) Markedness constraints, which favour phonological unmarkedness. OT assumes that markedness constraints outrank faithfulness constraints in early phonological acquisition (e.g., Smolensky 1996; Gnanadesikan 2004). A common result of an early Markedness >> Faithfulness ranking in L1 acquisition, is a situation described as Emergence of the Unmarked (McCarthy and Prince, 1994).

One commonly high ranked markedness constraint for the acquisition of syllable structure in early acquisition is *COMPLEX, which prevents branching structure within the onset of a syllable. Children resort to three different kinds of unfaithful mappings in support of *COMPLEX, these are: 1) cluster reduction, where one of the consonants is deleted, such as Gitanjali's [so] for *snow* (Gnanadesikan, 2004); 2) epenthesis, where a vowel breaks up the cluster (e.g. t[ə]ree); and 3) coalescence, where the distinctive features of the two consonants are merged into one, such as Gitanjali's [pɪkəw] for *twinkle* (Gnanadesikan, 2004) and [fok] for *smoke*. This is determined by the relative ranking of two faithfulness constraints, these are MAX, which prohibits deletion, and DEP, which prohibits insertion (McCarthy and Prince 1995). Children may differ in this respect, since Amahl (Smith, 1973) consistently has reduction, while Gitanjali has both deletion and coalescence. These differing outputs can be captured with the following rankings: (1) *COMPLEX, MAX >> DEP (resulting in epenthesis), (2) *COMPLEX, DEP >> MAX (resulting in deletion), (3) *COMPLEX >> DEP, MAX (resulting in epenthesis or deletion), and 4) *COMPLEX >> NO-COALESCENCE, MAX (Coalescence avoids deletion but still obeys the high ranking of *COMPLEX).

Although these rankings represent four plausible grammars, accounting for cluster reduction involves various other factors or constraints. Nonetheless, these observations show that the same output (i.e. basic CV(C) syllable structure) for onset clusters is satisfied in different ways across different children and different stages of development. It is therefore evident that there is a set of different constraints operating for the same output target (e.g. no consonant cluster) and this is commonly identified as phonological conspiracy. Despite this conspiratorial generalization, children differ in terms

of which individual cluster or singleton is acquired first and which is acquired last.

The focus of this paper, therefore, is to gain a wider understanding of why certain consonant clusters, such as initial /s/-clusters, are highly variable in production and pattern differently, both in L1 and L2 acquisition. For instance, it has been observed that children reduce onsets clusters to the least sonorous segment, and this reduction pattern is recognized as the Principle of Maximal Contrast (hereafter, PoMC) (Jakobson 1941:68), since there is a steep rise in sonority and results in an unmarked syllable structure. An example of the PoMC is where an obstruent+sonorant cluster is reduced to the least sonorous segment- i.e. [bu] for *blow*. Initial /s/-clusters, by contrast, follow two reduction patterns, they are either: 1) reduced to the least sonorous segment, such as [bun] for *spoon* (Gnanadesikan, 2004), or 2) reduced to the most sonorous segment, such as [lip] for *sleep* (Barlow and Dinnsen 1998), which is a marked syllable shape since the sonority distance is smaller between the onset and nucleus.

Secondly, some children delete the entire /s/-cluster which also results in a marked vowel-initial syllable shape, such as [un] for *spoon* (Barlow and Dinnsen 1998). Thirdly, according to some L1 studies, /s/-clusters are acquired relatively early (e.g. Stoel-Gammon and Dunn 1985), whereas in other studies they are acquired relatively late (e.g., Barlow and Dinnsen 1998; Smith 1973). The relative markedness of sounds and clusters in a language has usually been determined by the order of acquisition. In other words, children are expected to acquire the unmarked forms before the marked forms. However, /s/-clusters do not strictly follow this early Markedness>>Faithfulness constraint, thus it is difficult to determine what is (un)marked. All these facts reveal the special status of /s/-clusters.

In order to address the uniqueness of initial /s/-clusters, current developmental research has focused on other phonological domains, such as the structural representation of /s/-clusters. Hence, this paper seeks to address the following research questions: 1) Do /s/-clusters have a different structural representation from other non-/s/-clusters? 2) If it is different, which structural representation can it be assigned to? The data I provide, both from L1 and L2 acquisition, supports the supposition that /s/+STOP clusters are stored as a complex segment, and the analysis for this is worked out within an Optimality Theoretic approach.

2. Theoretical account of /s/-clusters

One of the several factors that determine the markedness of clusters, especially with /s/-clusters involves an appeal to sonority. The sonority scale as shown in (1) can enhance our understanding of the sonority profile of a syllable structure. For instance, every syllable has a Nucleus (i.e. vowel) which can possibly be surrounded on both sides by margin segments of lower sonority. Syllable margins are therefore subject to the sonority hierarchy

which maintains that segments are intrinsically orderable such that segments further up the hierarchy cannot occur outside segments lower on the hierarchy within a syllable. For instance, [l] is higher on the sonority hierarchy than [g], thus onsets like *[lg...] and codas like * [...gl] are both prohibited. This universal tendency is captured by the Sonority Sequencing Principle (hereafter SSP), which requires that onsets rise in sonority (ruling out *stop* and *lbik*) and codas fall in sonority (ruling out *sixth*). The SSP can be also be captured with the OT constraint shown in (2):

(1) Sonority scale (adapted from Selkirk 1984)
 [7] Glides > [6] Liquids > [5] Nasals > [4] Voiced Fricatives > [3] Voiceless Fricatives > [2] Voiced Obstruents > [1] Voiceless Fricatives

(2) SONORITY: All syllables must conform to a pattern of decreasing sonority from the nucleus to the margins.

Sonority is one of the several factors which contribute to the special status of /s/- sequences. Firstly, while most consonant sequences in English follow the SSP, certain initial /s/-sequences, such as; /s/+stop sequences violate the SSP. This is not supposed to happen and is quite exceptional, thus this makes /s/+stop clusters more marked than non-/s/ clusters in terms of sonority.

Morelli (1999), however, claims that Fricative+Stop (FS) clusters are the least unmarked, while Stop+Fricative (SF) clusters are marked despite the fact that it does not incur a violation of SONORITY. Morelli proposes that the unmarkedness of FS clusters can be attributed to sonority-independent factors such as language typology. The reason being is because languages that allow only one type of obstruent cluster always allow a sequence containing FS. Thus we would expect the following language typology:

(3) Fricative + Stop → Stop+ Fricative
 If a language has Fricative+Stop clusters, then it has Stop+Fricative clusters

However, as Morelli notes, there are no languages that behave in this way, since FS clusters, but not SF clusters, can be found in isolation, and SF always implies the presence of FS, thus making (3) false. Under this analysis, FS clusters are unmarked since they are fairly common cross-linguistically and much more common than SF clusters. This observation is also reflected in Turkish loanwords, since most /s/-cluster loanwords consist of /s/+stop clusters (see § 5). Apart from language typology, Morelli proposes that manner and place features should also be considered and therefore provides the constraints in (4), which are then put into perspective in Tableau 1. The cluster type marked with an arrow (→) is the winning candidate.

- (4) OCP [-continuant]: Tautosyllabic [-continuant] segments are disallowed in onset. Obligatory Contour Principle.
 OCP[+continuant]: Tautosyllabic [+continuant] segments are disallowed in onset.
 *SO: A tautosyllabic sequence of a stop followed by any obstruent is disallowed in onset.

Tableau 1.

	OCP [+cont]	*SO	OCP[-cont]
→ a. Fricative+Stop (e.g. English /st/)			
b. Fricative+Fricative (e.g. Italian /sf/)	*		
c. Stop+Fricative (e.g. Wichita /ks/)		*	
d. Stop+Stop (e.g. Khasi /pt/)		*	*

The Obligatory Contour Principle (OCP) prohibits homorganic sequences from occurring tautosyllabically. According to Morelli, FS is the most harmonic cluster type since it incurs no violations as shown in Tableau 1, thus it is less marked. It is plausible that Fricative+Stop clusters are unmarked in terms of language typology plus they do not violate the above OCP constraints. However, for the purpose of this section Fricative+Stop (i.e. /s/+stop) clusters will be considered ill-formed with respect to sonority. Research findings have also shown that L1 and L2 language acquirers are sensitive to sonority violations, thus sonority-dependent factors cannot be dismissed altogether.

Given the occurrence of clusters that do not conform to SONORITY or the OCP, these constraints are best characterized as a universal tendency rather than an absolute universal. For instance, within OT the universality of SONORITY and its violability is resolved given the premise that in OT all constraints are in principle violable. Another way of overcoming this violation is to regard /s/-clusters as having a different structural representation. For instance, some scholars claim that /s/+obstruent clusters are complex segments (Selkirk 1984, Lamontagne 1993) (see Figure (1b)) or that /s/ is an extrasyllabic segment (Levin 1985) (see Figure (1d)), thus constraints such as SONORITY or OCP become irrelevant altogether. Hammond (1999), by contrast, avoids these violations by formulating a separate licensing constraint ranking for /s/-clusters.

Apart from sonority-dependent violations, /sn-/ and /sl-/ sequences are also ill-formed, since share the same place of articulation and therefore violate the OCP constraint. In addition, /s/+nasal clusters do not conform to the SONDIST2 constraint (see (8) for definition), since the sonority distance between /s/+nasal clusters is 1 point: nasal=3, fricative=2, therefore 3-2=1. In addition, three-member /s/-clusters incur a violation of binarity (an onset may contain no more than two segments). However, the restrictedness of initial triconsonantal clusters only beginning with /s/ can be understood if one

assumes that /s/+stop sequences are complex segments. Secondly, /s/ is the only sound that may be followed by a nasal or a stop word-initially. All these facts reveal the special status of /s/-clusters. In the next section we will look more closely at the empirical research findings of /s/-clusters in L1 acquisition.

3. L1 acquisition

The acquisition of consonant clusters is a challenging task for children, and one way of dealing with these complex sequences is by reducing them to simple onsets. These incorrect productions may however vary across children and across cluster types. Normally developing children, as well as children with phonological disorders, exhibit similar types of error patterns, and such patterns tend to be unmarked in structure. An outline of the possible stages for cluster development for normally developing children is given by Greenlee (1974), in (5):

- (5) Stage 1: Deletion of entire cluster
- Stage 2: Reduction to a singleton
- Stage 3: Production of cluster with substitution of one segment
- Stage 4: Correct production

Stage 1 in (5) is not a common trait in L1 acquisition, since the deletion of the entire cluster will result in a more marked vowel-initial syllable shape. However, some L1 findings have shown that in some exceptional cases /s/-clusters are deleted altogether and this provides further evidence for the special status of /s/-clusters. Nonetheless, Stage 2 in (5): reduction to a singleton, is considered to be the most common error pattern both in normal and disordered development.

Many different accounts have been proposed to address the unusual developmental pattern of /s/-clusters, and recently the focus has shifted to their structural representation. Consequently, past research has suggested a variety of structures for branching onsets (as shown in fig. 1). True branching onsets, as in figure (1a), usually consists of obstruent+sonorant clusters which branch at the level of the onset (e.g. /fl/, /pr/). /s/-clusters, however, are argued to have a different structure from branching onsets and currently there stands to be two separate arguments. The first argument is that /s/-clusters are complex segments, as in figure (1b). Complex segments, like affricates, branch at the level of the segment and thus it is an inseparable single unit. The second argument, by contrast, is that /s/ is parsed as an adjunct (Barlow 2001)- i.e., outside the onset of the syllable, as in figure (1c). Figure (1c) is also parallel with figure (1d) which claims that /s/ is extrasyllabic –i.e. it is syllabified outside the onset of the syllable.

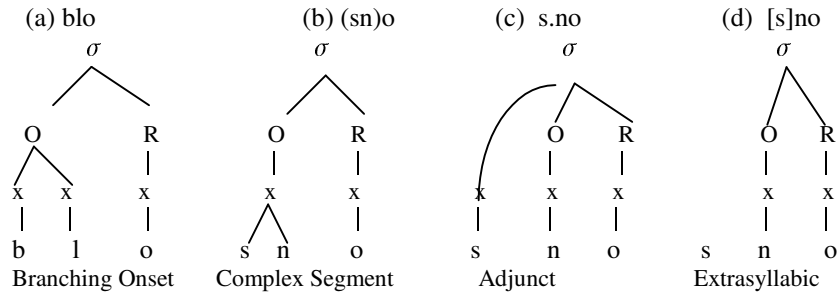


Figure 1. Structure of /s/-clusters

Let us now turn to the empirical findings, which support the various structural representations, assigned for /s/-clusters in figure 1. In the first study, Barlow and Dinnsen (1998) looked at the developmental pattern of Participant 24 who has a phonological deficit. The following conclusions are drawn from this study: 1) /s/+stop and /s/+nasal clusters are stored as a single unit underlyingly, and class them as a complex segment (see figure (1b)), and 2) /s/+approximant clusters are classed as branching onsets (see figure (1a)). Barlow and Dinnsen compiled three stages of acquisition data from Participant 24, as shown in (6):

(6) Participant 24

Stage 1 (4;9):

- (bl-) → b
- (pl-) → ∅
- (sw-)/(sl-) → ∅
- (sm-)/(sp-) → ∅
- (tʃ-) → ∅
- (dʒ-) → d
- l → l
- r → w

Stage 2 (5;0):

- (bl-) → b
- (pl-) → l
- (sw-)/(sl-) → w/l
- (sm-)/(sp-) → ∅
- (tʃ-) → ∅
- (dʒ-) → d
- l → l
- r → w

Stage 3 (5;3):

- (bl-) → bl
- (pl-) → pl
- (sw-)/(sl-) → w/l
- (sm-)/(sp-) → ∅
- (tʃ-) → ∅
- (dʒ-) → d
- l → l
- r → w

In stage 1 (in (6)), voiced stop+liquid clusters and voiced affricates are reduced to a singleton, while voiceless stop+liquid, voiceless affricates and all /s/-clusters are reduced to null. By Stage 2, voiced affricates and all other clusters, including for /s/+approximant clusters, are reduced to a singleton, while /s/+stop and /s/+nasal clusters and voiceless affricates are still reduced to null. Finally, by Stage 3, only non-/s/-clusters surface correctly, while /s/+stop and /s/+nasal clusters and voiceless affricates are still reduced to null, and voiced affricates and /s/+approximant clusters are reduced to a singleton.

One plausible reason as to why /s/-initial clusters do not surface may be contributed to the fact that fricatives emerge later in acquisition. In fact, many children avoid fricatives at the left-edge, whereas nasals and stops are favoured in this position (Grijzenhout and Joppen-Hellwig 2002). As a result

of this common finding, Barlow and Gierut (1999) propose a constraint against /s/, which is formulated as *S. Nonetheless, Barlow and Dinnsen attribute this differing pattern of /s/-clusters to their structural representation and conclude that /s/+nasal and /s/+stop clusters, like affricates, are represented as single unit underlyingly (i.e. complex segment). This is also why Participant 24 reduces /s/+stop and /s/+nasal clusters to null, since they are treated as an inseparable unit underlyingly. /s/+approximant clusters, by contrast, remain as true clusters, since they can be reduced to null or to a singleton.

In the second study, Barlow (2001), who looked at the development of KR- who also has a phonological deficit- adds a different dimension to the previous study and concludes that all /s/-clusters are adjunct clusters (see figure (1c)). Barlow compiled three stages of acquisition data from KR, which supports the adjunct structure of /s/ clusters, as shown in (7).

(7) KR's production

Stage 1 (3;6):	Stage 2 (3;11):	Stage 3 (4;3):
(bl-) → b	(bl-) → b	(bl-) → bl
(pr-) → p	(pr-) → p	(pr-) → pw
(sw-/sl-) → w/l	(sw-/sl-) → sw/sl	(sw-/sl-) → sw/sl
(sn-) → n	(sn-) → sn/sm	(sn-) → sn/sm
(st-/sk-/sp-) → k/k/p	(st-/sk-/sp-) → st/sk/sp	(st-/sk-/sp-) → st/sk/sp
(str-/skr-/spr-) → k/g/p	(str-/skr-/spr-) → st/sk/sp	(str-/skr-/spr-) → stw/skw/spw

Similar to Barlow and Dinnsen's study, the data in (7) shows that /s/-clusters are also acquired differently. However, unlike Participant 24, KR has acquired the /s/- clusters before the non-/s/ clusters. In Stage 1 and Stage 2, KR reduces stop+liquid clusters to a singleton and the general pattern is to retain the least sonorous segment (e.g. [bo] for *blow*) which is in line with the PoMC and therefore results in an unmarked syllable shape. In Stage 1 /s/-clusters, by contrast, are either 1) reduced to the least sonorous segment, such as [kaɪ] for *sky*, or 2) reduced to the most sonorous segment, such as [wɪm] for *swim*, which results in a marked syllable shape since the sonority distance is smaller.

By stage 2, /s/-clusters surface correctly, while all other branching stop + liquid sequences are still reduced to singletons due to the high ranking of *COMPLEX, which prevents consonant clusters from surfacing. Surprisingly, *COMPLEX does not seem to be active with /s/-clusters, since they surface correctly. Barlow therefore concludes that /s/-sequences are adjunct clusters since the /s/ is syllabified outside the onset of the syllable, thus they are not treated as complex onsets in KR's phonological grammar. In OT terms, Barlow differentiates /s/-clusters from other clusters by the differential treatment of constraint ADJUNCT-/s/ (Only /s/ is allowed in an adjunct, thus ADJ-/s/ likes *s.kai*, but not *b.lo*). Therefore, in Stage 2 /s/-clusters are parsed into an adjunct which allows for the satisfaction of high-ranked *COMPLEX and MAX (No deletion) at the expense of *ADJUNCT

(No adjuncts), as shown in Tableau 2 (Tableaux 2 and 3 are cited from Barlow (2001)):

Tableau 2.

/s.kai/ 'sky'	*COMPLEX	ADJ-/s/	MAX	*ADJ
a. [kai]			*!	
b. [skai]	*!			
→ c. [s.kai]				*

Stop+liquid clusters in Stage 2, by contrast, are treated as true clusters. Therefore undominated constraint ADJUNCT-/s/ ensures that /blo/ cannot surface with /b/ as an adjunct. Since adjuncts are disallowed here, the only way to satisfy *COMPLEX is through deletion, as shown in Tableau 3:

Tableau 3.

/blo/ 'blow'	*COMPLEX	ADJ-/s/	MAX	*ADJ
→ a. [bo]			*	
b. [blo]	*!			
c. [b.lo]		*!		*

I suggest that K is treating /s/-clusters as a complex segment, since all /s/-clusters surface correctly in stage 2. In this case, the ADJUNCT constraint can be removed altogether and replaced with the ranking in Tableaux 4 and 5. Since /s/-clusters are now associated with only one skeletal point in the underlying form, an output form in where the entire cluster surfaces will not violate *COMPLEX, whereas true clusters will violate *COMPLEX. This analysis can also be applied to Participant 24, where the deletion of the entire complex segment (i.e. /s/-clusters) is only one violation of MAX, whereas the deletion of the entire branching onset will incur two violations of MAX.

Tableau 4. KR

/s.kai/ 'sky'	*COMPLEX	MAX
a. [kai]		*
→ b. [skai]		

Tableau 5. KR

/blo/ 'blow'	*COMPLEX	MAX
→ a. [bo]		*
b. [blo]	*	

4. L2 Acquisition

Before we can analyse the Turkish L2 data it would be useful to look at the literature on L2 acquisition, especially of /s/-clusters. At present time, there stands to be no research that has examined the acquisition of English onset clusters by Turkish learners. Nonetheless, other cross-linguistic L2 research findings, especially of Arabic and Spanish speakers learning English, provide further evidence for the supposition that /s/-clusters are stored as a complex segment. Interestingly, both Arabic and Spanish speakers illustrate the use of prothesis, which is an uncommon repair strategy in L1 acquisition (except for the use of dummy syllables). For instance, Carlisle (1999) who examined the acquisition of English initial /s/-clusters by Spanish learners found that the Spanish/English interlanguage phonology applies prothesis to /s/-clusters only. For instance, *snow*, *slow*, and *steep* are pronounced as [esno], [eslo], and [estip].

However, in another notable study, again looking at the acquisition of English /s/-clusters, Broselow (1987) found that Egyptian speakers (dialect of Arabic) used prothesis only with /s/+stop clusters (e.g. [ʔɪstirit] for *street*). All other clusters, by contrast, were repaired by epenthesis (e.g. [sɪlaɪjd] for *slide*) since they conform to SONORITY

Similarly, in another notable study, again looking at the acquisition of English /s/-clusters, Cutillas Espinosa (2002) found that there is a varying degree of markedness between /s/+stop and /s/+liquid clusters. For instance, /s/+stop clusters were more difficult than /s/+liquid despite the fact that neither of these clusters are exhibited in Spanish. The reason for this prohibition is because /sl-/ violates the minimal sonority distance value for Spanish which is 4 (see (8)), and /sp-/ violates SONORITY since it presents an irregular sonority configuration. Overall, the study showed that the learners perform significantly better with /s/ + liquid clusters since it does not violate a universal principle (SONORITY). These findings also verify that L2 learners have Full Access to universal principles, such as SONORITY, regardless of their L1 experience.

- (8) SONDIST n : a language-specific constraint referring to minimal sonority distance. For English this is SONDIST₂ and for Spanish this is SONDIST₄

In another similar study Carlisle (1988) examined the production of the following three types of onset clusters: /sm/, /sn/, and /sl/. All of these /s/-clusters are marked in relation to Spanish since /s/-clusters are not exhibited in Spanish. Nonetheless, the study revealed that Spanish learners of English modified the more marked onset /sm/ and /sn/ significantly more than /sl/. In fact, according to the work of Greenberg (1978), obstruent+liquid onsets are less marked in relation to obstruent+nasal clusters since the sonority distance is larger in the former cluster.

Thus far we can deduce that /s/+stop and /s/+nasal clusters are more marked than /s/+approximant clusters and three-member onset clusters are respectively more marked than two-member onset clusters. However, the use of prothesis contradicts the claim that L2 learners are in the direction of the unmarked if we are to assume that the CV syllable structure is the maximally least marked syllable in natural languages (Battistella 1990; Cairns and Feinstein 1982). The use of prothesis does however indicate that syllable structures should be classified along a continuum of more marked or less marked rather than marked and unmarked. In that case, we can claim that the use of prothesis results in a less marked rather than a more marked syllable structure and most importantly it provides evidence that they are stored as a complex segment. The reasoning for this will be provided in the following sections.

5. Turkish Loanword phonology

At present time there stands to be no L2 research findings on Turkish speakers learning English. In order to fill in this gap this section will examine the treatment of loanwords in Turkish which exhibit /s/-clusters. This in return will to some degree enable us to predict the development paths Turkish learners might employ when acquiring English /s/-clusters.

It is an interesting fact that although Turkish does not allow complex onset clusters (Banguoğlu 1974: 53), it is possible to find two- and three-member Turkish loanword onset clusters (though very limited). These include, obstruent+approximant, /s/+stop, /s/+approximant, /s/+nasal (though very limited) and /s/+stop+approximant clusters. Due to this fact, I will label these existing loanwords as 'non-native' onset clusters. Non-native two- and three-member onset clusters in Modern Standard Turkish occur orthographically, however, orally they are repaired in two different ways. Depending on speaker variation, rising sonority clusters are usually repaired by epenthesis (as shown in bold forms in (9)), otherwise most often they are produced tautosyllabically in spoken language, especially by younger speakers. Thus epenthesis and zero-epenthesis is in free-variation. Nonetheless, falling sonority clusters, such as /s/+stop, are repaired by prothesis both orthographically and orally, as shown in (10).

(9) Rising sonority: internal epenthesis in Turkish loanwords

Orthography	Adult realisation	Gloss
<i>tren</i>	[t iren] ~ [tren]	'train'
<i>klüp</i>	[k ulyp] ~ [klyp]	'club'
<i>bluz</i>	[b uluz] ~ [bluz]	'blouse'

(10) Falling sonority: prothesis in Turkish loanwords

Orthography	Adult realisation	Gloss
<i>istasyon</i>	[ɪstasjɔn]	‘station’
<i>ıspanak</i>	[ɯspanak]	‘spinach’
<i>Istanbul</i>	[ɪstanbul]	‘Stambol’

Linguists such as Gouskova (2001) claims that there is no special structure associated with /s/-clusters that explains their resistance to epenthesis or prothesis. Instead Gouskova claims that the sonority profile of the cluster is what determines the best site in where epenthesis can apply. Thus, according to Gouskova rising sonority clusters are repaired by epenthesis and this is due to the high-ranking of SYLLABLECONTACT, see (11) for definition, and Tableau 6 for where it applies.

(11) SYLLABLECONTACT: The preference for sonority to fall across a syllable boundary. Sonority must not rise across a syllable boundary.

Tableau 6.

/tiren/ ‘train’	SYLLABLECONTACT	DEP
→ a. [ti.ren]		*
b. [it.ren]	*!	

Falling sonority clusters by contrast are repaired by prothesis due to the high ranking of CONTIGUITY, see (12) for definition and Tableau 7 for where it applies.

(12) CONTIGUITY: Elements adjacent in the input must be adjacent in the output.

Tableau 7.

/istasjɔn/ ‘station’	CONTIGUITY	DEP
a. [si.tasjɔn]	*	*!
→ b. [is.tasjɔn]	*	

On the whole, prothesis applies to /s/+stop clusters only. However, with some exceptions, prothesis also applies to rising sonority clusters such as /s/+liquid (e.g. Slav > *islav*) onset clusters but this is limited to one example. According to SYLLABLECONTACT, we would assume that a Turkish loanword such as *Slav* would be repaired by epenthesis, since you can not have rising sonority across a syllable boundary, yet this is not the case since this cluster is repaired by prothesis instead. Based on this counterexample we may therefore conclude that prothesis is applied to all /s/-clusters regardless of their sonority configuration and this is due to the high ranking of

CONTIGUITY. The use of prothesis therefore does not contradict our claim that /s/ clusters are stored as a complex segment since the elements adjacent in the input remain adjacent in the output even after prothesis has applied.

If we take this observation a little further we also notice that all the lexical items which have undergone prothesis in (10) are relatively old borrowings. Present-day /s/-initial Turkish loanwords, by contrast, are no longer repaired by prothesis (orthographically or orally) indicating that the old borrowings were initially altered at the surface level since the Turkish speaker's had no knowledge on the syllabification of /s/-clusters, simply because Turkish does not exhibit native-onset clusters. Therefore, prothesis is understood to be a temporary phase, since present-day /s/-initial loanwords are either repaired by epenthesis or surface faithfully as shown in (13). The diachronic (i.e. use of prothesis) and synchronic (i.e. zero-epenthesis) differences in Turkish loanwords strengthens the supposition that /s/-clusters are stored as a complex segment.

(13) Recent Turkish /s/-initial loanwords without prothesis

Orthography	Adult realisation	Gloss
<i>Stadyum</i>	[s <u>u</u> tɔdjʌm] ~ [stɔdjʌm]	'stadium'
<i>Skor</i>	[s <u>u</u> kɔr] ~ [skɔr]	'score'
<i>Spiker</i>	[sɪp <u>ɪ</u> ker] ~ [spɪker]	'speaker /commentator'
<i>Skandal</i>	[s <u>u</u> kandʌl] ~ [skandʌl]	'scandal'

6. Turkish L2 data

6.1. Subjects and procedure

The L2 data we present here looks at the acquisition of /s/-clusters by Turkish speakers learning English in Turkey. A total of 58 subjects took part in the experiment and the data was studied at two data collection times with a time span of six months. Since Turkish exhibits a very limited number of /s/-clusters it was not possible to exhibit a wide range of /s/-clusters in spontaneous speech. In order to overcome this limitation the data in this experiment was collected in the form of repetition tasks in where the subjects had to listen and repeat a wide range of onset clusters, both /s/ and non-/s/ clusters. The subjects consist of two age groups and two levels. The subjects are grouped in the following order: Group (1a) 16 beginner level children between the ages of 4 and 6; Group (1b) 16 intermediate level children between the ages of 7 and 8; Group (2a) 13 beginner level adults between the ages of 18 and 22; and Group (2b) 13 intermediate level adults between the ages of 18 and 22.

6.2. Results between-groups

Table 1 illustrates the set of target /s/-cluster words used in the repetition task. Those marked as acceptable /s/-clusters are exhibited in Turkish loanwords, while those marked as unacceptable are not. Table 2 illustrates the range of repair strategies used in stage 1, while Table 3 illustrates the findings for stage 2. The repair strategies marked in bold are classified as unusual repair strategies. The overall correct performance in percentages is also illustrated in Table 4. The numbers in bold font in Table 4 are acquired forms and this is measured by using an 80 per cent criterion method, also used by Eckman (1991) in L2 phonology. Thus, if learners use a certain structure correctly 80 per cent of the time, it is considered to be acquired. Correct usage is calculated by the number of correct attempts over the total number of attempts.

Table 1. Target words

Two-member acceptable /s/-clusters	Three-member acceptable /s/-clusters
[sp] <i>sparked, spoon, sportive</i> ; [st] <i>start, started, stadium, statistics, storm, stamped</i> ; [sm] <i>smarties, small</i> ; [sk] <i>scale, sketch</i> ; [sl] <i>slow, slogan, slav</i>	[str] <i>street</i> ; [spr] <i>spring</i>
Two-member unacceptable /s/-clusters	Three-member unacceptable /s/-clusters
[sn] <i>snow</i> ; [sw] <i>sweet</i>	[skw] <i>squeeze</i> ; [spl] <i>splash</i> ; [skr] <i>script, scream</i>

The scope of this section is to identify the development paths of Group (1) only, however, the results in Table 2, 3 and 4 includes Group (2) as well. This in return will illustrate how children differ from adults. The results of the present study revealed three main differences between Group (1) and (2). Firstly, Group (1) used the widest range of repair strategies, while Group (2) only used epenthesis and deletion (limited usage for three-member /s/-clusters). Notice, however, that the range of repair strategies Group (1) use decrease by stage 2 since they have had more positive input during the 6 months gap. Secondly, Group (2)'s phonological constraint ranking is Faithfulness>>Markedness, while Group (1)'s phonological constraint ranking is Markedness>>Faithfulness, since they use substitution and deletion. Thirdly, only Group (1) is found to be using prothesis. The use of prothesis indicates that CONTIGUITY is highly ranked in the phonological grammar of Group (1). Most importantly this ranking also provides evidence for the complex segment structure of /s/-clusters and the examples of prothesis will be considered in section 6.3

Table 2. The production of two- and three-member /s/-clusters in stage 1.

	S+ stop	S+ nasal	S+ approximant	S+stop+ approximant
Group (1a)	Deletion Epenthesis Prothesis Substitution Dummy syllable	Epenthesis Prothesis Substitution	Deletion Epenthesis Substitution	Deletion Epenthesis Prothesis Substitution Dummy syllable
Group (1b)	Deletion Epenthesis Prothesis Substitution	Epenthesis	Epenthesis	Deletion Epenthesis Substitution Metathesis
Group (2a)	Epenthesis	N/A	Epenthesis	Epenthesis
Group (2b)	N/A	N/A	N/A	Deletion Epenthesis

Table 3. The production of two-and three-member /s/-clusters in stage 2.

	S+ stop	S+ nasal	S+ approximant	S+stop+ approximant
Group (1a)	Epenthesis Prothesis Substitution Coalescence	Deletion Epenthesis Substitution	Epenthesis Substitution	Deletion Epenthesis Prothesis Substitution Dummy syllable
Group (1b)	Epenthesis	Epenthesis	N/A	Deletion Epenthesis Substitution
Group (2a)	Epenthesis	N/A	Epenthesis	Deletion Epenthesis
Group (2b)	N/A	N/A	N/A	N/A

Table 4. Overall Correct Performance

		2-member onset clusters					3-member onset clusters
		Acceptable			Unacceptable		Acceptable
		S+ Stop	S+ Nasal	S+ Approx	S+ Nasal	S+ Approx	S+stop+ Approx.
Group 1a	Stage 1	76	85	90	75	69	31
	Stage 2	92 ↑	85 ↔	94 ↑	94 ↑	88 ↑	64 ↑
Group 1b	Stage 1	89	100	96	100	94	72
	Stage 2	99 ↑	97 ↓	100 ↑	94 ↓	100 ↑	87 ↑
Group 2a	Stage 1	98	100	100	100	92	91
	Stage 2	100 ↑	100 ↔	100 ↔	100 ↔	77 ↓	94 ↑
Group 2b	Stage 1	100	100	100	100	100	98
	Stage 2	100 ↔	100 ↔	100 ↔	100 ↔	100 ↔	100 ↑

Key: **bold font**: acquired, regular font: not acquired, ↑ : (progression),

↓ : (regression), ↔ : (no change)

In order to properly assess these differences, it is also important to consider the overall correct performance rate of Group (1) and Group (2). Table 4 shows that Group (1a) has not acquired two-member /s/+stop, unacceptable /s/+nasal, unacceptable /s/+approximant and three-member /s/+stop+approximant clusters in stage 1, since their overall correct performance is below 80 per cent. All of the two-member /s/-clusters are problematic due to the high-ranking of *COMPLEX, which prohibits complex onsets. Nonetheless, this is not the only reason for their erroneous speech patterns. For instance, /s/+stop clusters are also problematic due to the fact that they violate SONORITY, thus SONORITY and *COMPLEX must be unranked in relation with one another for /s/+stop clusters. Further, /sn/ sequences are problematic since they violate SONDIST2 and most importantly /sn/ clusters are not exhibited in Turkish loanwords and so they are also problematic. Thus *COMPLEX and */sn/ (see (14)) are both highly-ranked and unranked in relation to one another. Both of these markedness constraints must in return outrank SONDIST2 since other /s/+nasal clusters such as /sm/, which also incur a violation of SONDIST2, are not problematic. Last but not least, /s/+illegal approximant clusters are problematic since

Turkish loanwords do not exhibit /sw/ clusters, thus the high-ranking of *[sw] (see (14)) and *COMPLEX prohibit /sw/ clusters from surfacing.

(14) Additional constraint

*[sn]: The following /s/-cluster is not exhibited in Turkish loanwords thus this negative constraint it is highly ranked.

*[sw]: The following /s/-cluster is not exhibited in Turkish loanwords thus this negative constraint it is highly ranked

Three-member /s/-clusters, which stand to be more marked in terms of margin length, are problematic since they violate *COMPLEX and SONORITY. Similarly, Group (1b) has also not acquired three-member /s/-clusters in stage 1, since their performance rate is below 80 per cent. Group (1b) have acquired all two-member /s/-clusters thus the high-ranking of *COMPLEX can not be the main reason why three-member /s/-clusters are not yet acquired. The data for both Group (1a) and (1b) implies that *COMPLEX might actually require a division into two part constraints that pertain specifically to the number of consonants in the clusters. The well-formedness constraints for this such particular behaviour can be formulated as *COMPLEX-[CC-] and *COMPLEX-[CCC-], but they will be shortened to *[CC-] and *[CCC-] for simplicity's sake as shown in (15). In this case we could conclude that *[CCC-] is highly-ranked for Group (1) in stage 1.

(15) Additional constraints

*[CC-]: No more than one consonant may associate to an onset position node.

*[CCC-]: No more than two consonants may associate to an onset position node.

Group (2), by contrast, has acquired all two-member and three-member /s/-clusters in stage 1. Notice that Group (2) do not use prothesis and use epenthesis or deletion instead. CONTIGUITY is therefore lowly-ranked in their phonological grammar.

By stage 2, Group (1a) has acquired all /s/-clusters except for three-member /s/-clusters and this is due to the high-ranking of *[CCC-] and SONORITY. Group (1b), by contrast, has acquired three-member /s/-clusters by stage 2 thus indicating that they have demoted *[CCC-]. Group (2) on the whole have acquired all /s/-clusters, however in stage 2 Group (2a)'s performance for unacceptable /s/+approximant clusters falls below 80 per cent. This example of regression is due to the fact that *[sw] is unranked with other markedness constraints. Thus far it is evident that Group (1b) and (2) have acquired all two- and three-member /s/-clusters. However, Table 2 and 3 shows that not all subjects in (G1b) have acquired /s/+stop, /s/+nasal and /s/+stop+approximant clusters. Further, two-member /s/-clusters are repaired by epenthesis (thus MAX >>DEP), while three-member /s/-clusters are repaired by deletion or epenthesis (thus MAX and DEP are unranked in

relation to one another). Similarly, certain subjects in Group (2a) are struggling with /s/+stop and /s/+stop+approximant clusters. Group (2a) repairs two-member /s/-clusters by epenthesis only (thus MAX>>DEP), while three-member /s/-clusters are repaired by deletion and epenthesis (thus MAX and DEP are unranked in relation to one another). This observation goes to show that not all Subjects have acquired all /s/-clusters unless the overall correct performance is 100 per cent.

6.3. Results within-groups

Thus far, it is evident that each subject in each group do not behave identically, and this section attempts to identify these individual differences. As we mentioned in Section 6.2, Group (1) is found to be using the widest range of repair strategies. Nonetheless, Group (1a)'s output stands to be more variable than Group (1b). For instance, S(subject)2(age 4) and S5(age 4), both from Group (1a), stand to be using the widest range of repair strategies for two-member /s/-clusters, as shown in (16) and (17).

(16) S2's variable output for two-member /s/-clusters in stage 1

<u>Output</u>	<u>lexical item</u>	<u>repair strategy</u>
[əstæmpt]	<i>stamped</i>	prothesis _CC
[əsmət]	<i>stamped</i>	prothesis _CC deletion C2
[spæmpt]	<i>stamped</i>	substitution C2 /t/→[p]
[sɑrtɪd]	<i>started</i>	deletion C2
[sɑ:t]	<i>start</i>	deletion C2
[səpu:n]	<i>spoon</i>	epenthesis C_C
[səkətʃ]	<i>sketch</i>	epenthesis C_C
[tʃətʃ]	<i>sketch</i>	substitution

(17) S5's variable output for two-member /s/-clusters in stage 1

<u>Output</u>	<u>lexical item</u>	<u>repair strategy</u>
[tɔ:m]	<i>storm</i>	deletion C1
[sɑ:v]	<i>Slav</i>	deletion C2
[səbɔ:tɪv]	<i>sportive</i>	epenthesis C_C
[səmə:l]	<i>small</i>	substitution C2 (/p/→ [b]) epenthesis C_C
[əstæm]	<i>stamped</i>	prothesis _CC
[əstɑ:tɪd]	<i>started</i>	prothesis _CC
[ɪsbu:n]	<i>spoon</i>	prothesis _CC
[əstɑ:]	<i>star</i>	substitution C2 (/p/→ [b]) prothesis _CC

[ʔstatɪstɪks]	<i>statistics</i>	prothesis _CC
[ʔskeɪl]	<i>scale</i>	prothesis _CC

S5's deletion pattern is in line with the PoMC since she deletes the most sonorous segment in *Slav* and *storm*. S2's deletion pattern for *started*, by contrast, is not in line with the PoMC, since the least sonorous segment is deleted. The deletion patterns illustrated in (18) and (19) for S10(age 5) represents a totally different pattern, since the /s/ is deleted in all environments regardless of its sonority configuration, both in stage 1 and 2. Notice that in stage 1, S10 adopts a similar pattern as Participant 24 (see (6)) and deletes the entire cluster with /s/+approximant clusters. This then raises the question as to whether /s/+approximant clusters are functioning as a complex segment. However, the fact that other repair strategies, such as prothesis, on the whole apply to /s/+stop clusters implies that /s/+stop clusters stand a better chance of having a complex segment structure. Thus S10's reduction patterns can simply be attributed to the fact that he has not yet acquired the /s/ segment and thus constraint *S is highly-ranked in his phonological grammar.

(18) Examples of deletion used by S10 in stage 1

<u>Output</u>	<u>lexical item</u>	<u>repair strategy</u>
[oʊ]	<i>slow</i>	C1
[teɪdɪəm]	<i>stadium</i>	C1
[dɑ:t]	<i>start</i>	C1

(19) Examples of deletion used by S10 in stage 2

<u>Output</u>	<u>lexical item</u>	<u>repair strategy</u>
[mɑ:ti:z]	<i>Smarties</i>	C1
[dɑ:t]	<i>start</i>	C1

Further, S22(age 7) from Group (1b), stands to be the only subject who is using the widest range of repair strategies. Notice however that S22 is distinctively different from Group (1a) since she does not use prothesis, as shown in (20).

(20) S22's repair strategies for two-member /s/-clusters in stage 1

<u>Subject</u>	<u>Output</u>	<u>lexical item</u>	<u>repair strategy</u>
S22	[səpu:n]	<i>spoon</i>	epenthesis C_C
	[dɑ:]	<i>star</i>	substitution (/t/ → [d]) deletion C1
	[stetʃ]	<i>sketch</i>	substitution C2 (/k/ → [t])
	[stɑ:p]	<i>sparked</i>	substitution C2 (/p/ → [t])
	[tæmpt]	<i>stamped</i>	deletion C1

The remaining part of this section will focus on the use prothesis since this provides crucial evidence for the complex segment structure of /s/-clusters. Most subjects in Group (1a) are found to be using prothesis both for two- and three-member /s/-clusters. Group (1b), by contrast, use prothesis only with two-member /s/-clusters, yet this is only limited to one Subject. The examples of prothesis are given in (21) (for Group (1a)) and (22) (for Group (1b)).

(21) Examples of prothesis used by Group (1a) in stage 1

<u>Subject</u>	<u>Output</u>	<u>lexical item</u>
S1(age 4)	[fəstɔ:m]	<i>storm</i> (dummy syllable)
S5	see (17)	
S6(age 4)	[ɪstæmpt]	<i>stamped</i>
	[əsbu:n]	<i>spoon</i>
	[əstɑ:]	<i>star</i>
	[ɪsketʃ]	<i>sketch</i>
	[əsmɔ:l]	<i>small</i>
S8(age 5)	[ɪsketʃ]	<i>sketch</i>

(22) Example of prothesis used by S28(age 7)-Group (1b) in stage 1

<u>Output</u>	<u>lexical item</u>
[əstæmpt]	<i>stamped</i>

By stage 2, only S5 from Group (1a) is found to be using prothesis, and in fact this is the only repair strategy she uses, as shown in (23). Thus the wide range of repair strategies S5 was found to be using in stage 1 (as shown in (17)) falls dramatically to only one repair strategy by stage 2. Notice, however that S5 is using prothesis with /s/+stop clusters only and this might indicate that only /s/+stop clusters are stored as a complex segment.

(23) Examples of prothesis used by S5 in stage 2

<u>Output</u>	<u>lexical item</u>
[ɪstɔ:m]	<i>storm</i>
[ɪstæmpt]	<i>stamped</i>
[ɪstɑ:tɪd]	<i>started</i>

Prothesis is also found to be used with three-member /s/-clusters, but this time only by Group (1a). The examples are given in (24) (for stage 1) and (25) (for stage 2).

(24) Examples of prothesis used by Group (1a) in stage 1

<u>Subject</u>	<u>Output</u>	<u>lexical item</u>
S1	[həskəp]	<i>script</i> (dummy syllable)
S5	[ɪskɪp]	<i>script</i>

	[ʌstri:t]	<i>street</i>
	[ʌskri:m]	<i>scream</i>
	[ækwi:z]	<i>squeeze</i>
	[əsprəs]	<i>spring</i>
S6	[ʌskɪt]	<i>scripts</i>
	[əsprɪŋk]	<i>spring</i>
	[ʌstrət]	<i>street</i>
	[ʌskri:m]	<i>scream</i>
	[əsplæʃ]	<i>splash</i>
	[ʌkwi:z]	<i>squeeze</i>

(25) Examples of prothesis used by Group (1a) in stage 2

<u>Subject</u>	<u>Output</u>	<u>lexical item</u>
S5	[ʌskɪpt]	<i>script</i>
	[əsprɪŋ]	<i>spring</i>
S6	[kʌskɪpt]	<i>script</i> (dummy syllable)
S8	[əstri:t]	<i>street</i>

Another unusual repair strategy we detect in the speech production of Group (1a) is the use of dummy syllables. See (21), (24) and (25) for examples. Notice however that dummy syllables are only used with /s/+stop clusters and they also function as prothesis. Other less common repair strategies include coalescence (e.g. *sportive* realised as [fɔ:tɪf] by S11(age 5)) and metathesis (e.g. *scripts* realised as [spɪktəs] by S22).

Overall, Group (1a) use prothesis with /s/+stop, /s/+nasal and /s/+stop+approximant clusters in stage 1. Group (1b), by contrast, use prothesis with /s/+stop clusters only. By stage 2, Group (1a) uses prothesis with /s/+stop and /s/+stop+approximant clusters only. Based on these findings we can conclude that /s/+stop clusters are stored as a complex segment, while /s/+nasal and /s/+approximant clusters are stored as branching onsets since they are not repaired by prothesis in stage 2. The reason why Group (1a) apply prothesis to /s/+nasal clusters in stage 1 is because it violates SONDIST2. It is also possible that they overgeneralize the use of prothesis in stage 1 just in the same way as Participant 24 had when she reduced all /s/-clusters to null in stage 1 (see (6)), and by stage 2 this only applied to /s/+stop and /s/+nasal clusters.

In the L2 acquisition data in §4 we found Iraqi speakers apply prothesis to /s/+stop clusters only, since they violate SONORITY. The Spanish learners, by contrast, apply prothesis to all /s/-clusters. The discussion on which /s/-clusters are stored as a complex segment is beyond the scope of this paper and is an area for further research. However, the treatment of /s/+stop clusters remains to be distinctively different from other /s/-clusters and this is due to fact that L1 and L2 acquirers are sensitive to universal constraint, such as SONORITY

Nonetheless, what we have intended to show in this section is the fact that children use a wider range of repair strategies than adults do. Moreover, we have also shown that the range of repair strategies decreases as the Subjects' level of correct performance increases. This is most paramount with Group (2b) since they use no repair strategies once they have acquired all /s/-clusters by stage 2. Interestingly, the L2 data from Group (1) correlates with the repair strategies used for old Turkish loanwords (i.e. prothesis with /s/+stop clusters), while the L2 data from Group (2b) correlates with the repair strategies used in Present-day Turkish loanwords (i.e. zero-epenthesis with /s/-clusters in stage 2). Initially, old Turkish loanwords were repaired by prothesis, however with more and more positive input the use of prothesis was short-lived. Nonetheless, both new and old Turkish loanwords provide evidence for the fact that /s/-clusters are stored as a complex segment and the reason for this is two-fold. Firstly, the use of prothesis implies that CONTIGUITY is highly-ranked and thus the segments can not be separated by epenthesis. Secondly, the fact that /s/-clusters surface faithfully both in Present-day Turkish loanwords and in the speech production of Group (2b) in stage 2. This in return shows that /s/-clusters an inseparable segment.

Overall, the use prothesis and dummy syllables was an unexpected finding and therefore deserved a closer analysis in this section. The use of prothesis can not be regarded as L1 transfer simply because Turkish does not exhibit onset clusters and Present-day loanwords are no longer repaired by prothesis. In order to account for this unexpected repair strategy we concluded that /s/-clusters (especially /s/+stop) are stored as a complex segment and in OT terms this can be accounted for by the high-ranking of CONTIGUITY.

7. Conclusion

The aim of this paper has been to look for a linguistic explanation for the irregular development patterns of /s/-clusters. The markedness of certain segments or consonant clusters is most often determined by sonority, language typology and order of acquisition. However, the order of acquisition can not determine the relative markedness of /s/-clusters, since the production of /s/-clusters is highly variable, both in L1 and L2 acquisition.

In order to address the uniqueness of /s/-clusters recent linguistic research has looked for other linguistic explanations, such as the structural representation of /s/-clusters. At present there stands to be more than one structural representation assigned to /s/-clusters. In this paper I have argued against the adjunct (or extrasyllabic) structure. Instead, I have argued that /s/+stop clusters are stored as a complex segment. New evidence for this has been provided from the Turkish L2 data we have introduced in § 6.

However, there still stands to be no fixed agreement on whether or not all /s/-cluster are stored as complex segment. Past research findings have a lot to contribute to this current debate, however, these studies have often looked at

one discipline (e.g. L1 acquisition). Obviously much more work remains to be done, but as a first step this paper has attempted to incorporate both L1 and L2 developing systems. The next step would be to look at developed systems as well in order to posit wider generalizations. Nonetheless, all of the conspiratorial generalizations, both from L1 and L2 acquisition, outlined in this paper, shows how /s/-clusters function differently from other branching onsets and they may therefore potentially be classed as a complex segment.

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