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ON THE REPRESENTATIONAL STATUS OF /S/-CLUSTERS

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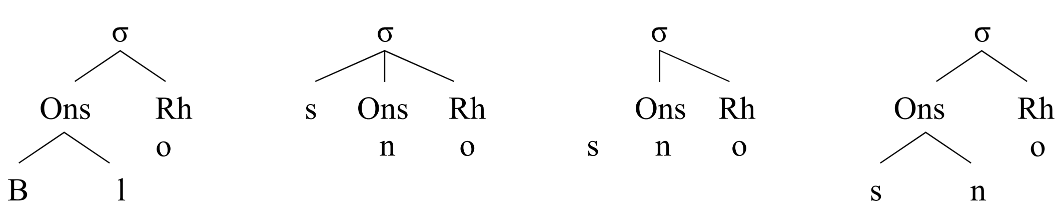
This work argues against the claim that a structural distinction is the necessary source of the divergent patterns of behavior attested in /s/- and non-/s/ consonant sequences. Previous treatments of linguistic phenomena as wide-ranging and manifold as Sanskrit reduplication (Steriade 1988), Italian allomorphy (Davis 1990), and the acquisition of English word-initial clusters (Barlow 2001) have all converged on the assumption that /s/-sequences require structural representations that are different from those assigned to other consonant clusters. In each of these cases however, I show that analyses of the data that do not assume a structural distinction are simpler, and either have more explanatory power, or generate more accurate predictions.

1 Introduction

Debate over the representational status of /s/-clusters has been ongoing for some time now. Past research has suggested a diversity of structures, a handful of which are depicted below. The symbol 'σ' represents the syllable constituent, 'Ons' the onset node, and 'Rh' the rhyme.

(1)
a. *blo* b. *s.no* c. *[s]no* d. *sno*



Non-/s/ clusters are typically—and for the most part uncontroversially—assigned the structure in

(1a), in which all initial consonants are parsed into the onset node. Consonant sequences beginning with /s/, however, are often assigned a different structure. In (1b), initial /s/ is parsed as an adjunct—a direct dependent of the syllable node (Kenstowicz 1994; Barlow 2001). Contrast this with (1c), in which /s/ is left stray, or unsyllabified (Steriade, 1982, 1988; Davis, 1990). The alternatives suggested in (1b-c) are responses to the cross-linguistically differential patterning of /s/-clusters versus other cluster types with respect to a number of linguistic phenomena. The general assumption underlying these proposals is that because /s/-clusters behave differently than other consonant sequences, they must have a different structural representation.

The position I take in this paper is that this line of reasoning is flawed. Different patterns of behavior suggest that the grammar must maintain *some* difference between /s/- and non-/s/ clusters. It is a non sequitur though, to say that a structural distinction must hold and must be the source of difference, especially when (i) various non-structural methods of enforcing the required difference exist, and (ii) non-structural sources of difference already implicitly coexist with structural distinctions in all of the analyses that call for a structural difference. Based on this reasoning, I will argue that the representation in (1d) is the correct structure: /s/-clusters are parsed in the same fashion as all other consonant sequences (cf. 1a).

It is important to note at the outset that the analysis I suggest is not simply an ad hoc movement of the locus of difference from the domain of structures to elsewhere in the grammar. That is, I do not propose structural syncretism for its own sake, merely because it can be done, but rather because abolishing the structural distinction between /s/- and non-/s/ sequences actually allows for better, more insightful analyses that have more explanatory and predictive power. These advantages will be illustrated as we proceed.

The arguments in favor of structural syncretism are organized as follows. In §1, the acquisition of English word-initial onsets is considered (Barlow 2001). Assuming an Optimality-Theoretic (OT) framework, I will demonstrate that a stochastic learning algorithm that presupposes a structural difference between /s/- and non-/s/ sequences cannot correctly predict the production stages that are most commonly attested during the course of cluster acquisition. When all clusters are assigned the same structure, this problem disappears. §2 deals with Sanskrit perfective reduplication (Steriade 1988). In this case, an analysis that relies on structural differentiation is able to make the correct predictions. It does so, however, by positing two separate methods—one for handling /s/ + obstruent clusters, and a stipulation for dealing with all other cases. I show that an OT analysis that treats all consonant sequences as structurally identical is able to account for the same facts using a single, non-stipulative mechanism. The final evidence in favor of structural syncretism comes from Italian, and is dealt with in §3. Davis (1990) accounts for the distribution of the two allomorphs of the Italian masculine definite article—*il* and *lo*—by positing an /s/ versus non-/s/ structural distinction, then stipulating that one structure selects *il*, while the other takes *lo*. In an OT analysis of the same data set, I demonstrate that the distribution of *il* and *lo* can be explained via the interaction of a handful of syllabic markedness constraints. This analysis significantly does not depend upon a structural distinction.

2 The acquisition of English word-initial consonant sequences

Barlow (2001) provides an OT account of the acquisition of word-initial clusters for KR, a child with a phonological deficit (Elbert et al. 1990). The defining symptom of KR's deficit is delayed progression through the stages of acquisition. In spite of this delay, KR's productions at each stage are representative of the normal pattern of acquisition; i.e. KR's behaviors are normal, they just come later than for most children. KR's productions at each of three distinct stages are recorded in (2):

(2)

Word	**Stage 1 (3; 6)**	**Stage 2 (3; 11)**	**Stage 3 (4; 3)**
bootie	buti	buti	buti
reading	widiŋ	widin	widiŋ
tub	kʌbi	tʌbi	tʌbi
blow	bo	bo	blo
snow	no	sno	sno
sky	kai	skai	skai
spray	pei	spei	spwei

In Stage 1, all word-initial clusters are reduced to singletons. Stage 2 is characterized by the production of two-place /s/-clusters, with all other clusters still reduced to singletons. In Stage 3, all clusters surface unreduced. Note that all cluster types pattern similarly during Stages 1 and 3. The difference in behavior is only apparent in Stage 2.

Barlow accounts for the productions in (2) by appealing to the constraint set given in (3), and offering hand-rankings for each of KR's three stages. 'Hand-ranking' refers to ad hoc rankings that are achieved without the explicit use of a ranking algorithm. This is the method used in most OT research to date. It will be contrasted later with the more principled machine-rankings generated by a stochastic learning algorithm.

(3)

Constraint	**Requirements**
*ADJ(UNCT)	No adjuncts
ADJ(UNCT)-/s/	Only /s/ is allowed in an adjunct
*COMP(LEX-ONSET)	No complex onsets
MAX	No deletion

The constraints shown in (3) do not represent the full set used in Barlow's analysis. Four more constraints—*COR, *M/OBS, *M/SON and IDENT—are required in order to capture all of the detail in the data in (2). Of these four, only IDENT is not used in the simulations described later in §1.1-1.4.[1] IDENT regulates featural identity between input and output so that, for example, when IDENT is ranked high, an underlying /r/ surfaces as [r], and not some other segment. Unfortunately, I have been unable to successfully incorporate it into the models in §1.1-1.4. This should not be considered a detrimental flaw, however. The focus of this research is on the behavior of /s/-clusters versus that of other consonant sequences. In the case of English word-initial cluster acquisition, the difference between the two cluster types comes in Stage 2 where, as noted above, two-place /s/-clusters surface, while other consonant sequences reduce to singletons. Modeling this difference—the deletion of segments in one group versus their retention in another—does not require being able to predict exactly which segment deletes or appears. This work is mainly concerned with whether segments do or do not appear, not with the identity of the segments that surface. As such, the loss of IDENT is not significant. Further, keeping IDENT, as Barlow does in her analysis, does not guarantee the successful prediction of the identity of a surface segment. KR's Stage 3 form *spwei*, for instance, is incorrectly predicted to be *sprei*:

(4)

/sprei/	ADJ-/s/	MAX	IDENT	*COMP	*ADJ
☹ a. s.prei				*	*
☞ b. s.pwei			*!		*

Apparently, even when IDENT is included, it is unable to guarantee selection of the attested form.

The tableaux in (5-6) illustrate the details of Barlow's Stage 2 ranking. Readers interested in the rankings she posits for Stages 1 and 3 should consult the Appendix.

(5) Stage 2 /s/-clusters:

/s.kai/	*COMP	ADJ-/s/	MAX	*ADJ
a. kai			*!	
b. skai	*!			
☞ c. s.kai				*

[1] The other constraints not shown in (3) —*COR, *M/OBS and *M/SON— are ommitted from (3) and from subsequent discussion for purposes of expositional ease only. They are still operative in all analyses presented in this paper—both Barlow's and mine. See the Appendix for definitions of each constraint, and full tableaux showing their place in the various ranking hierarchies.

For /s/-clusters—as in *sky*—candidate (5a), *kai*, is eliminated by MAX, while candidate (5b), incurs a fatal violation of *COMP. Candidate (5c), *s.kai,* is chosen as optimal because it is able to simultaneously satisfy *COMP and MAX by parsing /s/ into an adjunct (indicated here, as elsewhere in the paper, with a period after the adjoined consonant). For non-/s/ sequences in the same stage however, a different outcome obtains.

(6) Stage 2 non-/s/ clusters:

/blo/	*COMP	ADJ-/s/	MAX	*ADJ
☞ a. bo			*	
b. blo	*!			
c. b.lo		*!		*

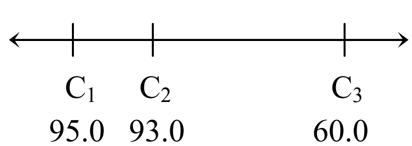
In (6), the complex onset candidate—(6b), *blo*—is again ruled out by undominated *COMP. This time though, parsing the initial consonant of the sequence into an adjunct is not an option: candidate (6c) attempts this very strategy, and is eliminated as a result of a fatal violation of ADJ-/s/. The only option left for non-/s/ sequences is reduction to a single consonant, as in (6a).

To summarize Barlow's analysis, /s/-sequences are distinguished from other consonant clusters in two ways: (i) via the structural assignments depicted in (1a) and (1b), and (ii) through the use of a constraint that differentially treats the two types of clusters: ADJ-/s/ likes *s.kai*, but not *b.lo*. The fact that Barlow relies on two separate means to account for the different patterning of word-initial clusters during acquisition constitutes a redundancy. This redundancy additionally damages our ability to correctly predict KR's attested stages of acquisition when the job of constraint-ranking is taken out of human hands and given to a stochastic learning algorithm.

2.1 Stochastic Optimality Theory

The term Stochastic OT is more or less synonymous with Boersma's Gradual Learning Algorithm (GLA; Boersma & Hayes 2001; Boersma 1997). There are a number of features that the GLA possesses that are relevant for this research. First, in GLA models of learning, constraints are ranked on an arbitrary, *continuous scale*. Some constraints are closer together, while others are further apart.

(7) Continuous constraint ranking:



This feature, in conjunction with a parameter known as *noise*, allows for the modeling of optionality, gradience in grammatical judgments, and the gradual changes that occur through the course of child language acquisition. Under the GLA, the ranking given in (7) will, for the most part, be stable. However, variation can occur at the time of evaluation, when a small amount of normally-distributed noise is introduced into the ranking scale. The effect of this noise is negligible when two constraints are far apart on the scale—as are C_2 and C_3. In this case, C_2 will dominate C_3 on the vast majority of evaluations—as in standard OT. The difference between standard and stochastic OT comes when two constraints are close together. For example, the effect of noise will be apparent in the relationship between C_1 and C_2. C_1 will still dominate C_2 on most evaluations, but in a significant subset of cases, the ranking will be reversed. This gives us the possibility of learning a grammar that will allow multiple legal productions based on the same input, depending on which ranking emerges during evaluation.

Another important feature of the GLA is *error-driven learning*. A GLA learner compares the forms her grammar currently judges to be optimal with adult target forms. If the two are not identical—i.e., if there is an error—she adjusts her constraint ranking by slightly lowering constraints that are violated in the correct adult form, and slightly raising constraints that are violated by her current, incorrect form. This procedure allows the learner's grammar to eventually converge on a ranking that produces the target adult form. The distance of each slight adjustment along the ranking scale is determined by setting the *plasticity* parameter. Higher plasticity means larger ranking adjustments; lower plasticity equals smaller adjustments.

One additional assumption made in all of the subsequent models must be introduced. Many researchers involved in OT-theoretic acquisition work posit an initial state of learning in which a wholesale domination of faithfulness by markedness occurs (Gnanadesikan 1995; Boersma & Levelt 1999; Curtin & Zuraw 2001). In order to accurately model the beginning stages of acquisition, this ranking must hold. Acquisition can be described as the gradual overtaking of markedness constraints by low-ranked faithfulness constraints, but not the other way around; children's developmental progression simply does not include initial productions that faithfully reproduce adult forms. In keeping with this idea, all simulations discussed below assume initial markedness over faithfulness. Doing so gives us the gradual promotion of MAX over time that is needed to model KR's data.

An example of a GLA learner at work is given in (8-10). The tableau in (8) shows the initial state of the grammar of a child attempting to produce a monosyllabic word with a complex onset. Plasticity is set to 0.01.

(8)

/CCV/	*COMP = 100.00	MAX = 90.00
a. CCV	*! →	
☞ b. CV		← *

The constraints *COMP and MAX begin separated by a distance of 10 units on the ranking scale. At each trial, the learner hears the target adult form /CCV/. The learner then attempts to reproduce that form. With *COMP outranking MAX, the target form cannot surface: faithful candidate (8a) is eliminated due to a fatal violation of undominated *COMP, leaving candidate (8b) as optimal. This incorrect outcome triggers reranking. Because the target form—candidate (8a)—violates *COMP, *COMP is demoted by 0.01 units. Conversely, MAX, which is violated by a candidate that does not match the target, gets promoted by 0.01 units. This, of course, leaves the learner in the same position as before any learning took place:

(9) Results after one learning trial:

/CCV/	*COMP = 99.99	MAX = 90.01
a. CCV	*! →	
☞ b. CV		← *

In (9), the (b) candidate is still incorrectly chosen as optimal. Many more trials are needed before the necessary ranking of MAX over *COMP obtains, as in (10).

(10) The state of the grammar after thousands of trials:

/CCV/	MAX = 100.00	*COMP = 90.00
☞ a. CCV		*
b. CV	*!	

At this point, MAX and *COMP are far enough away from one another that MAX >> *COMP will hold for the vast majority of evaluations—candidate (10b) will surface at a vanishingly small rate, on the order of that expected for a speech error.

2.2 Experiment 1: adjuncts for /s/-clusters only[2]

Barlow (2001) relies on hand-ranking in order to arrive at the constraint hierarchies that characterize each of KR's three stages of acquisition. Experiment 1 is an attempt to use a more principled method of ranking—stochastic OT in the form of the GLA—to achieve

[2] All experimental results were obtained using OTSoft (Hayes et al., 2000).

the same result. I assume the same constraint set that Barlow does—minus IDENT—and the same target structures: the /s/ in /s/-clusters is parsed into an adjunct, while all other word-initial consonant sequences occur as true onsets—see (1b) and (1a).

A short reminder: the simulations introduced here and in the following two sections have certain limitations due to the fact that IDENT is not included in the constraint set. They are not necessarily able to predict which specific segments will surface in an optimal form. They can however distinguish among general classes of segments—e.g. obstruents versus sonorants—so that the attested trend towards reduction to the second element in all /s/-clusters, and to the least sonorous element in all other consonant clusters is accurately predicted. All experiments rely on the parameters given below:

(11)

Faithfulness Constraints start at	0.00
Markedness Constraints start at	300.0
Plasticity	0.1
Noise	2.0

These are not the only parameter settings available; others lead to the same outcomes discussed below. I have, however, specifically chosen these because they provide a cleaner view of the stages that occur. Under any combination of settings, the shape of learning will be similar to what we find using the settings in (11). Increasing noise though, or decreasing the starting distance between faithfulness and markedness constraints will lead to stages that are less crisp—i.e. to situations in which constraints are more likely to overlap, so that for each input, multiple outputs will ensue under the same ranking. The settings in (11) minimize this problem, and give rise to well-defined stages in which a single output form is obviously dominant.

2.2.1 Input

A typology of English word-initial consonant sequences was devised based on the patterns of violations different kinds of words received under Barlow's full constraint set. The table in (12) shows these violations, along with example targets for each type of consonant sequence.

(12)

Type	Target	*COMP	*ADJ	ADJ-/s/	MAX
P = noncoronal obstruent	buti				
R = sonorant	widiŋ				
T = coronal obstruent	tʌbi				
PR = noncoronal obstruent + sonorant	blo	*			
sR = /s/ + sonorant	s.no		*		
sO = /s/ + obstruent	s.kai		*		
sOR = /s/ + obstruent + sonorant	s.pwei	*	*		

Since only four of the eight constraints that Barlow uses are shown in the table, a number of cluster types, e.g. sR and sO, appear to have identical violation patterns. This, however, is not the case. Each of the seven word-initial cluster types is unique.[3] The GLA additionally allows inputs to be weighted by frequency. Frequencies for the seven types of consonant sequences were calculated based on numbers available in the CELEX database.[4] These frequencies are recorded below.

(13)

Type	Example	Frequency (%)[5]
P	bootie	44.02
R	reading	29.18
T	tub	18.72
PR	blow	4.79
sR	snow	1.03
sO	sky	1.21
sOR	spray	0.39

Essentially what the information in (12) and (13) together means is that 44.02% of the inputs that the learner hears will be words that have violation patterns identical to *bootie*; 29.18% will have violation patterns consistent with *reading*; 18.72% will violate the same constraints as *tub*, and so on. In stochastic OT, frequency drives learning, so these numbers will be important in that the algorithm will tend to home in on ranking solutions

[3] The algorithm is trained on the full pattern of violations—not the abbreviated patterns given in (12), (17) and (21). As a result, it is 'aware' of the differences between, for example, sR and sO clusters. Consult the Appendix for the full violation patterns used in each experiment.

[4] http://europa.eu.int/celex/htm/celex_en.htm

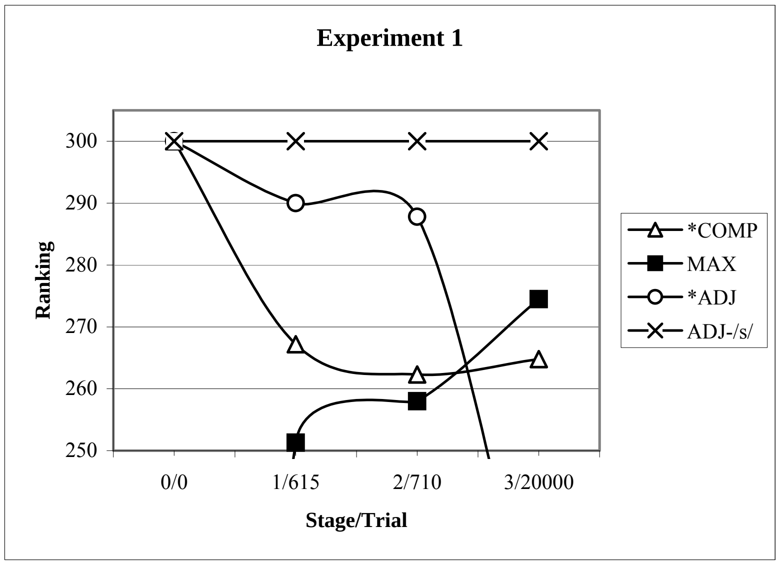
[5] Thanks to Ezra Van Everbroek for writing the PERL script used to calculate these frequency numbers.

for high-frequency items before fine-tuning the grammar to account for lower-frequency forms.

2.2.2 Results

The constraint rankings that occur through the course of learning are given in (14).

(14) Experiment 1 rankings:



While KR's Stage 1 and 3 rankings are correctly predicted by the algorithm, the ranking that Barlow assigns to Stage 2—given in (5) and (6)—is not achieved. The problem is that *ADJ is too high in the ranking hierarchy. In Barlow's Stage 2 hand-ranking, it occurs in the lowest stratum, but the GLA puts it in the second highest. This has the effect of eliminating all target adjunct candidates—like (15c) below:

(15) Stage 2 constraint ranking predicted in Experiment 1:

/s.kai/	ADJ-/s/	*ADJ	*COMP	MAX
☞ a. kai				*
b. skai			*!	
c. s.kai		*!		

The only available option is to reduce the cluster to the least sonorous element—as in candidate (15a), *kai*. (16) gives the complete results for Experiment 1. Highlighting indicates cells that are of interest; incorrect predictions are marked with a star.

(14) Experiment 1 predictions:

Type	Example	Stage 1 615 trials	Stage 2 710 trials	Stage 3 20,000 trials
P	bootie	buti	buti	buti
R	reading	widiŋ	widiŋ	widiŋ
T	tub	tʌbi	tʌbi	tʌbi
PR	blow	bo	bo	blo
sR	snow	no	*no	s.no
sO	sky	kai	*kai	s.kai
sOR	spray	pei	*pei	spwei

2.3 Experiment 2: All consonant sequences are assigned adjuncts

In Experiment 1, positing separate structures for word-initial /s/- and non-/s/ consonant sequences caused the GLA to fail to correctly predict KR's attested Stage 2 productions. We will see that this is in fact the cause of Experiment 1's lack of success after considering the results of Experiment 2, where the structural distinction given in (1b) and (1a)—adjuncts for /s/-clusters, but not for other clusters—is done away with. Instead, an all-adjunct analysis is proposed: the first consonant of every cluster will be parsed into an adjunct.

This change represents the sole difference between Experiments 1 and 2, and leaves us with a slightly different set of targets and violation patterns than that depicted in (12) for Experiment 1. Changes from Experiment 1 are highlighted in gray in (17).

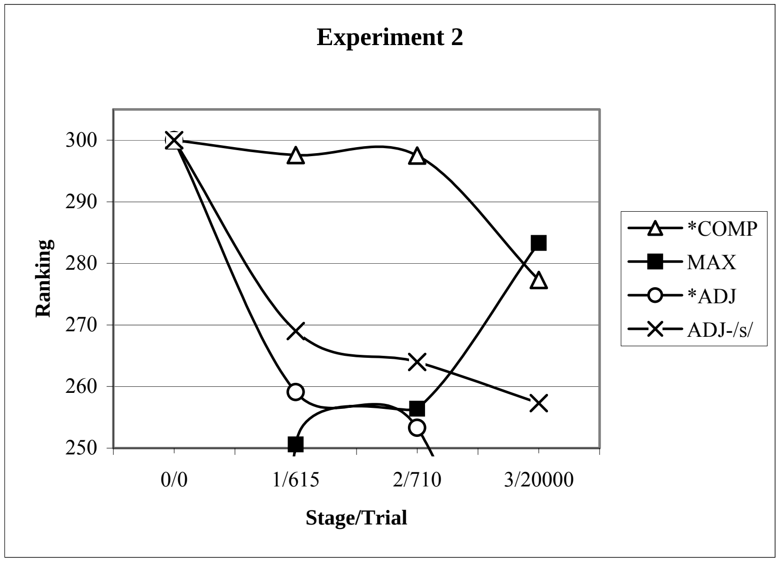
(17) Experiment 2 violation patterns:

Type	Target	*COMP	*ADJ	ADJ-/S/	MAX
P	buti				
R	widiŋ				
T	tʌbi				
PR	b.lo		*	*	
sR	s.no		*		
sO	s.kai		*		
sOR	s.pwei	*	*		

2.3.1 Results

Given the input described in (17), the constraint rankings illustrated in (18) ensue:

(18) Experiment 2 constraint rankings:



Productions based on these rankings are given below. Outcomes that differ from those in Experiment 1 are highlighted:

(19) Experiment 2 predictions:

Type	Example	Stage 1 615 trials	Stage 2 710 trials	Stage 3 20,000 trials
P	bootie	buti	buti	buti
R	reading	widiŋ	widiŋ	widiŋ
T	tub	tʌbi	tʌbi	tʌbi
PR	blow	bo	bo	b.lo
sR	snow	no	s.no	s.no
sO	sky	kai	s.kai	s.kai
sOR	spray	pei	s.pei	spwei

The GLA successfully predicts the attested productions for each cluster type, in each stage. Note that (18) gives a Stage 2 constraint ranking that is nearly identical to the hand-ranking posited by Barlow, the only difference being that the ranking calculated by the GLA is slightly more articulated: *COMP dominates ADJ-/s/ here, whereas in Barlow's ranking they occurred in the same stratum. This change has no effect on evaluation; the two grammars are functionally equivalent. Note that adding the articulation given by the GLA to the tableaux in (5) and (6), reproduced below, does not affect the outcome.

(5) Experiment 2 /s/-clusters:

/s.kai/	*COMP	ADJ-/s/	MAX	*ADJ
a. kai			*!	
b. skai	*!			
☞ c. s.kai				*

(6) Experiment 2 non-/s/ clusters:

/blo/	*COMP	ADJ-/s/	MAX	*ADJ
☞ a. bo			*	
b. blo	*!			
c. b.lo		*!		*

2.3.2 Discussion

Why is the algorithm able to mimic Barlow's ranking in Experiment 2 and not in Experiment 1? The answer to this question lies in the different violation patterns input to the algorithm in each experiment for three key constraints: *ADJ, ADJ-/s/ and *COMP. These differences are summarized in (20):

(20)

	Target	*ADJ	ADJ-/S/	*COMP
Experiment 1	blo			*
Experiment 2	b.lo	*	*	

In Experiment 1, assigning non-/s/ sequences a target structural representation where the consonant cluster occurs as a complex onset leads to a violation of *COMP. When the first consonant is parsed into an adjunct however—as in Experiment 2—a complementary pattern of violations occurs. *ADJ and ADJ-/s/ incur violations, and *COMP does not. Recall that learning is error-driven in the GLA and that constraints that the target candidate violates are demoted through the ranking hierarchy. When non-/s/ consonant sequences are assigned complex onset status, this means that an additional 4.79% of the inputs the algorithm sees are telling it to demote *COMP. On the other hand, because *ADJ and ADJ-/s/ are not violated by this same target structure, there is less information available telling the algorithm to demote these constraints. The result is that they are demoted slowly, if at all, while *COMP falls more quickly. Under the target representation in Experiment 2 however, the opposite outcome obtains. Now the algorithm is receiving 4.79% more information asking it to demote *ADJ and ADJ-/s/, and less information telling it to demote *COMP. The consequence is that *ADJ and ADJ-/s/ get demoted more quickly than *COMP. This in turn brings about Barlow's Stage 2 ranking—*COMP, *ADJ-/s/ >> MAX >> *ADJ—and allows the model to correctly predict the different Stage 2 patterns of non-/s/ and /s/-cluster production attested for KR. Different violation patterns in each experiment lead to accelerated or decelerated constraint movement during learning, which in turn affects possible ranking outcomes.

One caveat about the results obtained in Experiments 1 and 2. The crucial discovery here seems to be that it is quite difficult to find a situation wherein the targets and violation patterns used in Experiment 1 are able to generate the correct Stage 2 productions. After running dozens of simulations, I have yet to discover a parameter set that predicts a correct, well-defined Stage 2 under these conditions. This is not to say that this is an impossible task; it may well be feasible. If such a parameter set is discovered, it would force a weaker version of the argument made here. Currently, given the results of Experiments 1 and 2, it appears that positing separate structures for /s/- and non-/s/ sequences is undesirable for two reasons: (i) because it leads to incorrect predictions in Stage 2, and (ii) because it constitutes a redundancy in the grammar—the structural difference and ADJ-/s/ *both* serve to differentiate /s/- from non-/s/ clusters. If a parameter set is discovered though, that allows for the correct predictions to be made while at the same time maintaining a structural difference, then argument (i) fails. Abolishing the structural distinction would still be advisable in this situation—but only for the reason given in (ii).

2.4 Experiment 3: all consonant sequences are assigned to complex onsets

The relationship between *ADJ and ADJ-/s/ is such that the first constraint militates against a set of forms containing a certain kind of structure, while the second licenses a subset of those same forms. This relationship is not specific to adjunct structures alone. It can be applied to countless other situations. If we were to posit a constraint called COMP-/s/ for example, that licensed only /s/ as the first element in a complex onset, then *COMP and COMP-/s/ would be related in the same way that *ADJ and ADJ-/s/ are. *COMP would militate against complex onsets, while COMP-/s/ would license a subset of all complex onsets, namely just those that begin with an /s/. The fact that we are able to describe consonant sequences using either set of constraints suggests the possibility of an alternative to the all-adjunct analysis indicated by the results of Experiment 2. That is, the solution to the problem of correctly predicting KR's attested stages of acquisition may not be to assign both /s/- and non-/s/ sequences to adjunct structures. It could be that the more general solution is just to give both cluster types the *same* structural interpretation. If this is the case, then an accurate GLA model that uses targets that parse every consonant sequence into a true complex onset should be possible. Such a model would make use of *COMP and COMP-/s/ rather than *ADJ and ADJ-/s/, since the latter constraints are vacuously satisfied when no target structural representations contain an adjunct.

2.4.1 Input

The violation patterns used in Experiment 3 are identical to those used in Experiment 2, and are listed in (21).

(21) Violation patterns for Experiment 3:

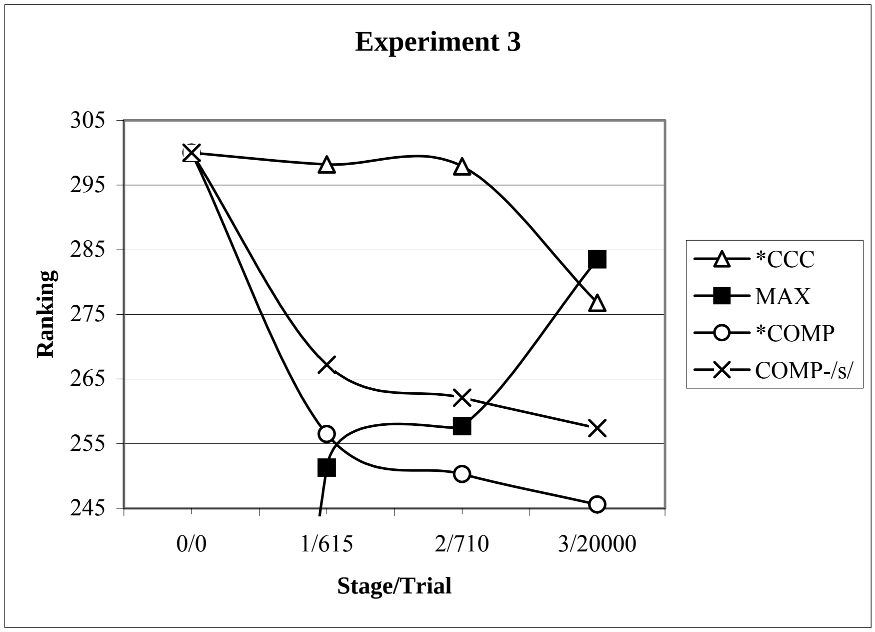
Type	Target	*CCC	*COMP	COMP-/s/	MAX
P	buti				
R	widiŋ				
T	tʌbi				
PR	blo		*	*	
sR	sno		*		
sO	skai		*		
sOR	spwei	*	*		

Three constraints however, have been renamed to reflect the fact that all targets are now complex onsets. Under the all-adjunct analysis, only three-place clusters as in *straw* and *spray* violated *COMP. In the all-complex-onset analysis of Experiment 3 though, violations of *COMP are replaced with violations of *CCC, which disprefers three-place onsets. *ADJ from Experiment 2 is replaced by *COMP—both constraints are violated by all cluster types. And finally, COMP-/s/ is substituted for ADJ-/s/: only PR clusters violate either constraint.

2.4.2 Results and Discussion

Reranking over the course of learning is depicted in (22), and predicted productions for each stage are given in (23), with the relevant cells again highlighted in gray.

(22) Experiment 3 constraint ranking:



(23) Experiment 3 predictions:

Type	Example	Stage 1 615 trials	Stage 2 710 trials	Stage 3 20,000 trials
P	bootie	buti	buti	buti
R	reading	widiŋ	widiŋ	widiŋ
T	tub	tʌbi	tʌbi	tʌbi
PR	blow	bo	bo	blo
sR	snow	no	sno	sno
sO	sky	kai	skai	skai
sOR	spray	pei	spei	spwei

The correct outcome occurs because the combination of *CCC, *COMP and COMP-/s/ under an all-complex-onset analysis is functionally equivalent to the constraint set of *COMP, *ADJ and *ADJ-/s/ in an all-adjunct analysis. If Experiment 2 succeeds, then Experiment 3 will too because the violation patterns have not changed; the algorithm is basing its constraint reranking on the exact same information in both cases (compare the tables in 17 and 21). The tableaux in (24) and (25) show the details of the complex-onset analysis for Stage 2.

/S/-clusters

(24) Experiment 3, Stage 2 /s/-clusters:

/skai/	*CCC	COMP-/s/	MAX	*COMP
a. kai			*!	
☞ b. skai				*

(25) Experiment 3, Stage 2 non-/s/ clusters:

/blo/	*CCC	COMP-/s/	MAX	*COMP
☞ a. bo			*	
b. blo		*!		*

For a word like *sky*, reduction to a singleton is not an option. The Stage 2 ranking of MAX over *COMP ensures that candidate (24b) will be preferred over candidate (24a). For a non-/s/ cluster as in *blow* however, reduction is still favored. High-ranked COMP-/s/ dislikes complex onsets that begin with /b/, or any segment other than /s/, so candidate (25a) is chosen as optimal in this case. These outcomes coincide with KR's actual Stage 2 behavior.

Since Experiment 3 succeeds because *COMP and COMP-/s/ are related in precisely the same manner as *ADJ and ADJ-/s/, it could be claimed that the act of proving that an all-complex-onset analysis works actually undermines such an analysis. Reducing all consonant sequences to *any* of the structures given in (1) should be possible so long as the relationship that holds between *COMP and COMP-/s/ is maintained in whatever other constraint duo is posited. Why, for example, should an all-complex-onset analysis be privileged over an all-adjunct, or all-stray analysis? There are two answers to this question. First, translating from all-adjuncts to all-complex-onsets phrases the analysis in terms of the structure that has the most evidence in its favor. The majority of researchers assume structures like those in (1a) and (1d). The other possibilities—adjuncts and strays—are generally used to account for data that was thought to be intractable in other ways, e.g. the English, Sanskrit and Italian data that are the focus of this paper. What I have shown here in §1 is that there is no reason to entertain anything other than an all-complex-onset analysis in accounting for the facts of English cluster acquisition; it is not necessary to multiply our structure inventory beyond the most basic, unmarked structure—the complex onset. The second motivation for dismissing all-adjunct or all-stray analyses, is that choosing to frame our analysis in terms of complex onsets has certain learnability benefits. This topic will be discussed in more detail in §4.

In the stochastic OT models provided by the GLA in Experiments 2 and 3, we see that the two-pronged method of cluster distinction advocated in Barlow (2001)—positing a structural difference *and* a constraint that is able to tell /s/-sequences apart from non-/s/ sequences—is unnecessary. Instead, it appears that, given the theory of learning embodied by the GLA, the notion of structural difference can—and indeed must—be abandoned in order to arrive at the correct series of developmental stages. The question that will be dealt with in subsequent sections of this work is whether this kind of simplification can be expanded to deal with phenomena in other domains and languages in which structural differentiation has been assumed to be necessary.

3 Structural representation in Sanskrit perfective reduplication

Steriade's (1988) account of the Sanskrit perfective reduplicant crucially asserts a structural distinction between /s/ + obstruent sequences, and other initial clusters. As in the case of English initial clusters, structural nonuniformity represents an unnecessary complication. The two structure types can be conflated, and a successful analysis is still possible. In fact, the resulting analysis is arguably simpler than the one provided by Steriade, as I will show.

The Sanskrit perfective demonstrates two patterns of reduplication, both of which are characterized by the prefixation of a CV syllable to a stem. The less common pattern is restricted to stems beginning with an /s/ + obstruent (sO) sequence. For this class of items, a base-initial s_1O_2 sequence always reduces to O_2 in the onset of the reduplicant; e.g. s_1k_2and becomes k_2a- s_1k_2and. Additional examples appear in (26):

(26)

Stem	Perfect	Meaning
skand	ka-skand	to leap
sta	ta-sta	to stand
sprd	pa-sprd	to contend
sput	pu-spu	to burst
scut	cu-scut	to drip

All other verb stems beginning with a consonant cluster reduplicate by reducing the base's initial consonant sequence to the first element; e.g. k_1r_2and reduplicates as k_1a-k_1r_2and. Further examples are given in (27):

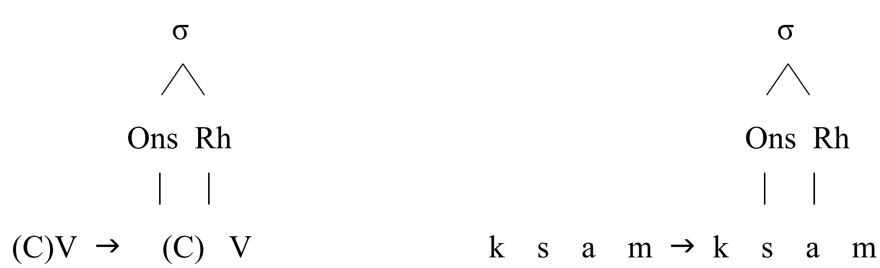
(27)

Stem	Perfect	Meaning
snih	si-snih	to be sticky
smi	si-smi	to smile
sru	su-sru	to flow
syand	si-syand	to move on
srat	sa-srat	to slacken
prac^{h}	pa-prac^{h}	to ask
dru	du-druv	to run
d^{h}ma	da- d^{h}ma	to blow
ksam	ka-ksam	to endure
ksip	ki-ksip	to throw
tsar	ta-tsar	to approach stealthily
psa	pa-psa	to devour
mluc	mu-mluc	to set
myaks	mi-miks	to be situated
vyac	vi-vyac	to extend
vyad^{h}	vi-vyad^{h}	to pierce
ksnu	ku-ksnu	to whet
krand	ka-krand	to cry

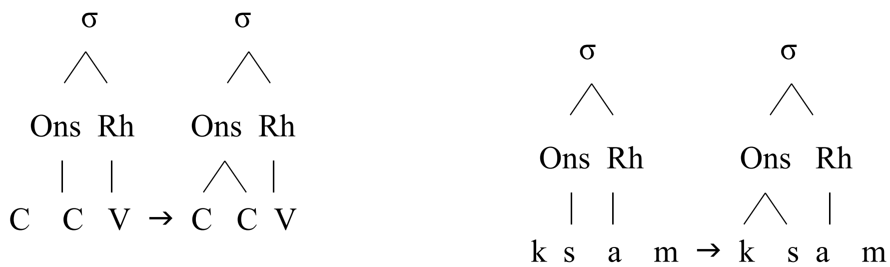
Steriade makes use of two components, one feeding the other, to explain the facts in (26-27). The first is the syllabification algorithm introduced in Steriade (1982). In that work, syllabification is claimed to follow from the interaction of a handful of simple, universal rules, along with language-specific instantiations of the Sonority Sequencing Principle (SSP)—a constraint that enforces a rise in sonority from a syllable's boundaries to its nucleus. A word like the Sanskrit verb *ksam*, for instance, receives the structural description given in (28d) as a result of the application of rules (28a-c):

(28)

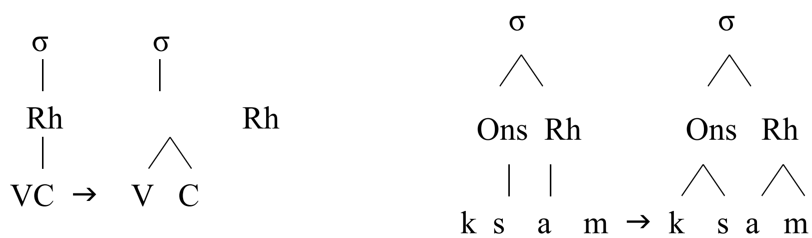
a. CV Rule



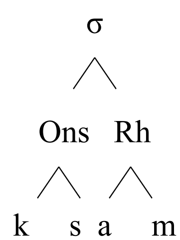
b. Onset Rule (subject to SSP)



c. Coda Rule (subject to SSP)



d. Output



In (28a), the CV Rule generates a simple CV syllable around the nucleus provided by /a/. The Onset Rule then acts on the output of the CV Rule, and subsumes /k/ under the onset node, creating the complex onset /ks/. Finally, the Coda Rule applies, creating a branching rhyme with /m/ parsed as a coda. The diagram in (28d) shows the final, fully syllabified output.

The Onset Rule adds additional consonants to a word's onset node based on SSP requirements that differ from language to language. While the essence of the SSP—that sonority increases from a syllable's boundary to its nucleus—is universal, different languages instantiate it in different ways. For example, some languages require that adjacent consonant segments in an onset margin show an abrupt increase in sonority, as in the word *pew* /pjiw/, where sonority jumps quickly from the low-sonority voiceless stop /p/, to the very sonorous glide /j/. In other languages, more gradual increases are tolerated; adjacent segments in an onset can be relatively close together in sonority, as in a British pronunciation of *new* /njiw/, in which two sonorants—/n/ and /j/—occur side by side. Steriade (1982) formalizes the SSP requirements that Sanskrit imposes on its onset clusters in terms of a language-specific division of the sonority scale, and what she calls Minimal Sonority Distance (MSD)—a constraint on how much difference in sonority must be maintained between adjacent onset segments:

(29) Sanskrit sonority scale:

noncoronal stops	coronal stops	coronal fricatives	m	n	l	w	r, y
1	2	3	4	5	6	7	8

(30) Sanskrit restriction on MSD:

> Given the sonority hierarchy in (29), adjacent onset segments must have an MSD $\geq +1$.

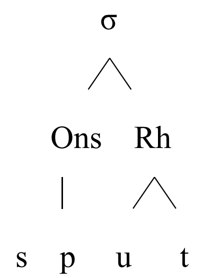
The Onset Rule and the SSP information given in (29-30) interact as follows. For any C_1C_2V sequence where the CV rule has already created a C_2V syllable, the Onset Rule can incorporate C_1 into the syllable if the sonority value of C_1 subtracted from the sonority value of C_2 is greater than or equal to one. The /k/ in *ksam* for instance, can legally become part of the onset according to the following calculation:

(31) $k_1 = 1$
$s_2 = 3$
$C_2 - C_1 \geq 1$
$3 - 1 = 2$

The scale in (29) assigns /k/ a value of 1, and /s/, 3. One subtracted from three equals two, which is greater than or equal to +1. Sanskrit's MSD is met, so the Onset Rule applies, resulting in the structure in (28b). All of the initial consonant clusters in the stems in (27) meet the MSD requirement. Consequently, they are all syllabified as complex onsets.

The initial sequences in the stems given in (26) are treated differently, however. In those cases, the initial consonant—always an /s/—cannot be syllabified. The result is a stray:

(32)



The initial /s/ cannot be incorporated into the syllable by the Onset Rule because all /s/ + obstruent clusters violate the MSD:

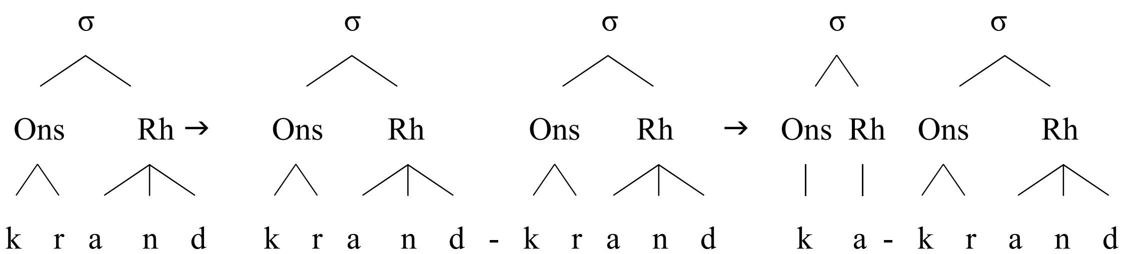
(33) $s_1 = 3$
$p_2 = 1$
$C_2 - C_1 \geq 1$
$1 - 3 = -2$

The MSD requires a distance of at least +1. Here though, the outcome is –2. This blocks application of the Onset Rule, leaving /s/ stranded. This result obtains for initial /s/ in all of the stems listed in (26). A simpler way of interpreting the MSD in Sanskrit is simply to note that Sanskrit onsets must manifest a rise in sonority. This is essentially what Steriade is enforcing when she sets the MSD to +1. Because the initial consonant sequences of the stems in (27) show an increase in sonority as they near the vowel, they are syllabifiable as onsets. The initial sequences in the stems in (26) on the other hand, actually evidence a decrease in sonority. This is not allowed in onsets, so /s/ in all cases is left stray.

The second component needed to account for the facts in (26-27) is an analysis of perfective reduplication. In Steriade (1988), the syllabification rules just described feed what she calls the Full Copy model. Full Copy is characterized by “complete copying: the possibility of partial or selective copying—copying a subset of the base tiers or a subset of the base units—is rejected” (1988: 78). This means that in *every* case of reduplication, the first step is to copy the entire base into the reduplicative morpheme—segments as well as the accompanying prosodic structure. After this is completed, Steriade invokes a general principle that eliminates elements in the reduplicant that are not allowed by the reduplicative template. Recall that the template for the Sanskrit perfective is a CV syllable. This means that the perfective of a verb like *krand* is derived as follows:

(34)

a. Stem b. Full Copy c. Template Satisfaction



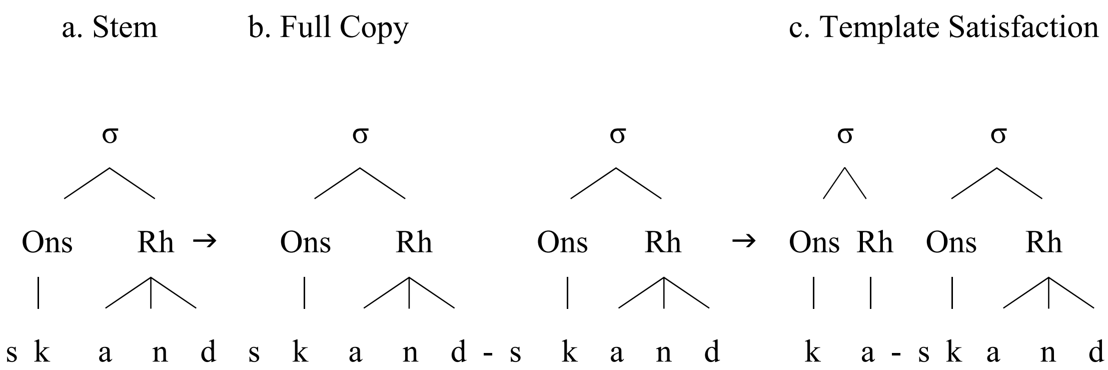
After the base is completely copied into the prefix in (34b), template satisfaction occurs. The perfective template obviously cannot be satisfied if prefixal *krand*'s /nd/ remains—it is therefore deleted. Reduction of the complex onset /kr/ to /k/ requires a bit more work though. In principle, retaining either /k/ or /r/ as the single onset consonant of the reduplicative morpheme would satisfy a CV template. Steriade must invoke additional machinery in order to account for the fact that /kr/ reduces to the first consonant. This comes in the form of a parameter and a stipulative matching procedure that targets non-initial onset consonants for deletion:

(35) Parameter: complex onset
Setting: unmarked (complex onsets disallowed)
Matching procedure: To satisfy templatic and syllabic markedness requirements, target non-initial consonants for deletion

This gives us all of the reduplicated items in (27), but only by invoking an ad hoc procedure, specifically tailored to the task.

If a stipulation allows for reduction to the first consonant in a CC onset for the verbs in (27), we would expect that a similar technique could be brought to bear to account for the pattern in (26) of reduction to the second consonant. This, however, is not the case. The pattern in (26) follows from Steriade's (1982) syllabification algorithm. Syllabification, according to the procedure outlined above, ensures that the /s/ in all stems beginning with /s/ + obstruent clusters ends up stray, or unsyllabified. Stray /s/ is vulnerable to deletion because an unsyllabified consonant does not match the perfective's CV-syllable template. In this way, reduction to the non-initial consonant is accounted for via an interaction between syllabification rules and template satisfaction. A sample derivation is depicted in (36):

(36)



The representation in (36a) acts as input to reduplication. Note that /s/ is left stray according to Steriade's syllabification procedure. Full Copy—in (36b)—simply copies over segmental and prosodic information from the base into the reduplicative prefix. In (36c), the copied material is reduced to a CV syllable. Since /k/ is already syllabified as an onset in /ka/, and /ka/ satisfies the perfective's CV-syllable template, unlicensed stray /s/ in the prefix deletes, leaving us with well-formed *ka-skand* as the output. All items in (26) are derived in this manner.

To summarize Steriade's Full Copy analysis, initial /s/ + obstruent sequences in the Sanskrit perfective morpheme reduce to the second consonant as a result of an interaction between syllabification—which leaves /s/ stray in these cases—and a general principle of template satisfaction that eliminates unlicensed material. All other initial cluster reductions in the reduplicant are accounted for by template satisfaction—but only if the stipulation holds that non-initial onset consonants are the ones that delete. This difference in treatment between /s/ + obstruent clusters and other clusters disappears if the structural distinction that Steriade volunteers is abolished.

3.1 A Structurally Syncretic Account

I propose an OT analysis of the data in which syllabic markedness constraints that are operative elsewhere in the grammar eliminate onset clusters and coda consonants in the reduplicative affix, and reduction of onset clusters to a singleton is regulated in all cases by the SSP. This approach has the advantage over Steriade's of achieving the same results without (i) having to posit a structural distinction, and (ii) having to explain the reduction of onset clusters in the reduplicant via two separate mechanisms.

The approach that is fleshed out below was proposed in schematic form in Kager (1999). In that work, Kager analyzes the reduction of the base that occurs in Sanskrit perfective reduplication as a case of *the emergence of the unmarked* (TETU; McCarthy & Prince 1994). This phenomenon can be accounted for by ranking constraints referring to input-output faithfulness, markedness, and base-reduplicant identity as follows:

(37) Kager's ranking:

FAITH-IO >> MARKEDNESS >> IDENT-BR

High-ranked FAITH ensures that stems that are underlyingly marked—e.g. that contain codas and/or complex margins—will retain this markedness on the surface. Because markedness outranks the BR constraints though, reduplicative affixes—which are unregulated by FAITH—will be repaired, if necessary, to satisfy markedness. These interactions give rise to TETU: a reduplicative morpheme will retain some semblance of identity with its base, but only insofar as doing so does not violate constraints on markedness. Given, for instance, a Sanskrit base like *krand* that contains a coda and two complex margins, we have seen that the reduplicant surfaces in the form that is least marked—a CV syllable: *ka-krand*.

Fleshing out Kager's ranking means identifying exactly which markedness constraints are operative in-between the FAITH-IO and IDENT-BR constraint classes. The fact that *krand*'s coda, for instance, does not appear in the reduplicant can be explained by appealing to NO-CODA. But how can we enforce reduction of the affix's complex onset to *ka* rather than *ra*? This is the problem that Steriade accounted for in two different ways, depending on whether the onset consisted of an /s/ + obstruent sequence or not. Here however, I claim that all cases can be handled using a universal ranking based on the SSP:

(38) *M/SON >> *M/SPIR >> *M/STOP

This type of ranking was first suggested by Prince & Smolensky (1993). The constraints it uses are defined as follows:

(39)

Constraint	**Requirements**
*M(ARGIN)/SON(ORANT)	No sonorants in onsets
*M(ARGIN)/SPIR(ANT)	No spirants in onsets
*M(ARGIN)/STOP	No stops in onsets

In lay terms, (38) says that stops are the preferred margin segments, followed by spirants, then sonorants.

This method of formalizing the SSP may initially appear to be quite different from that proposed by Steriade (1982). Her approach and the one discussed here, however, are in fact transparently relatable. Each of the three *MARGIN constraints listed in (39) corresponds to a specific range of segments from the Sanskrit sonority scale we saw in (29), reproduced below:

(40)

*M/STOP (1–2) *M/SPIR (3) *M/SON (4–8)

noncoronal stops	coronal stops	coronal fricatives	m	n	l	w	r, y
1	2	3	4	5	6	7	8

Steriade makes an 8-way sonority distinction in order to ensure that the /s/ in verb stems beginning with /s/ + obstruent sequences is left stray. This prosodic representation then feeds into her Full Copy model of reduplication, where /s/ ends up being eliminated in the reduplicant during the process of template satisfaction. What I will demonstrate in the coming paragraphs, is that the elimination of /s/ can alternatively be explained using a simpler 3-way sonority distinction among stops, spirants and sonorants. For all other verbs beginning with consonant sequences, the elimination in the reduplicant of the second base consonant can likewise be handled by this system. Contra Steriade (1988), no additional stipulations are necessary.

The reduction to *ka* in *ka-krand* is regulated by universal ranking of the *MARGIN constraints:

(41)

/RED-krand/	*M/SON	*M/SPIR	*M/STOP
☞ a. ka-krand	*		**
b. ra-krand	**!		*

As are the reductions in the /s/ + obstruent group, e.g. *sta* (to stand):

(42)

/RED-sta/	*M/SON	*M/SPIR	*M/STOP
☞ a. ta-sta		*	**
b. sa-sta		**!	*

The tableaux in (41-42) constitute arguments in favor of the ranking *M/SON, *M/SPIR >> *M/STOP. The additional ranking of *M/SON >> *M/SPIR that is required in order to achieve the full articulation given in (38) is justified below:

(43)

/RED-smi/	*M/SON	*M/SPIR	*M/STOP
☞ a. si-smi	*	**	
b. mi-smi	**!	*	

Altering (38) would potentially lead to incorrect outcomes in all three of the evaluations in (41-43). As it stands however, (38) guarantees reduction to the least sonorous element.

The interactions in (41-43) are to explain why base-initial clusters reduce to one consonant or another in the Sanskrit perfective affix. Answering this question, however, does not tell us why reduction happens in the first place. To accomplish this, we must appeal to an additional constraint interaction:

(44)

/RED-sta/	*M/SPIR	MAX-BR
☞ a. ta-sta	*	*
b. sta-sta	**!	

MAX-BR requires that a reduplicative morpheme copy its entire base. Violations are assessed for each uncopied segment. Candidate (44a) incurs a violation of MAX-BR because it fails to copy /s/ from the base. This violation is overridden however, by higher-ranked *M/SPIR, which favors (44a) over (44b). Under the ranking of *M/SPIR >> MAX-BR, reduction is obligatory. Any candidate that retains excess consonants in the reduplicant's onset will incur a fatal violation of *M/SPIR or, by transitivity, *M/SON.

Summary tableaux are given in (45-46).[6] NO-CODA can be ranked anywhere without affecting the outcome of evaluation.

(45) /s/ + obstruent clusters:

/RED-skand/	*M/SON	NO-CODA	*M/SPIR	*M/STOP	MAX-BR
a. kas-kand		**!		**	***
b. sa-skand		*	**!	*	***
c. ska-skand		*	**!	**	**
d. skand-skand		**!	**	**	
☞ e. ka-skand		*	*	**	***

(46) All other clusters:

/RED-krand/	*M/SON	NO-CODA	*M/SPIR	*M/STOP	MAX-BR
a. kak-rand	*	**!		*	***
b. ra-krand	**!	*		*	***
c. kra-krand	**!	*		**	**
d. krand-krand	**!	**!		**	
☞ e. ka-krand	*	*		**	***

The (a) candidates in both (45) and (46) represent alternative syllabifications of the optimal candidates shown in (e). Parsing what would normally be the first onset consonant of the base as the coda consonant of the prefix creates an additional coda, and leads to a fatal violation of NO-CODA. The (b) candidates explore the possibility of reducing the onset cluster of the base to a different consonant than in the optimal forms in (e). Both of these options are ruled out based on the ranking in (38): the least sonorous of a pair of consonants will always be preferred, e.g. *ka-skand* > *sa-skand*. In (c), *ska-skand* and *kra-krand* represent attempts to preserve the onset clusters of the base in the reduplicant. This option fails though because having more consonants in a margin leads to more violations of *M/SON, *M/SPIR and *M/STOP, which eventually lead to elimination. Finally, in (d), we see total satisfaction of MAX-BR—complete

[6] Assume undominated FAITH-IO, ANCHORING-BR, CONTIGUITY-BR, and ALIGN-RED-LEFT throughout.

reduplication. Candidates choosing this option fall short for the same reason as the (c) forms, and additionally accrue fatal violations of NO-CODA. The optimal (e) candidates represent the best possible solution to the problem of multiple constraint satisfaction posed by Sanskrit.

Note that both the analysis presented here and Steriade's (1988) treatment are able to explain the empirical facts in (26-27). I contend, however, that the approach described here is superior because all cases of cluster reduction are now naturally subsumed under the same machinery—the SSP-based ranking of *M/SON >> *M/SPIR >> *M/STOP. The SSP is already a required element in Steriade's approach. As a result, my analysis does not add any new mechanism, and simplifies Steriade's interpretation of the SSP by reducing her arguably ad hoc 8-way sonority distinction to one that involves only three basic levels. There are two additional benefits that accrue based on the analysis I propose. The first is that the stipulation that Steriade offers in (35) to account for non-/s/ sequence cluster-reduction becomes unnecessary. The second is that her /s/- versus non-/s/ structural distinction is rendered obsolete. This last finding is in keeping with the evidence from the GLA models described in §1, and with the overall thesis of this work—that the structural distinction suggested in previous research is an altogether avoidable complication.

4 Intervocalic sibilant clusters and the distribution of *il* and *lo* in Italian

Thus far we have looked at the possibility of doing away with structural distinctions that occur word-initially in English and Sanskrit. In §1, for example, evidence was presented that suggested that a structural difference need not—and indeed must not, as far as GLA learning is concerned—be posited between initial /s/-sequences and other initial consonant sequences. The data discussed in §2 extends this claim by showing that a structural distinction between /s/ + obstruent and other clusters is not necessary in order to account for the patterns of word-initial cluster reduction that occur in Sanskrit perfective reduplication. We now turn to a case involving differential cluster behavior in an intervocalic environment.

Davis (1990) proposes that the co-occurrence of Italian nouns with one of two allomorphs of the Italian masculine definite article (*il* or *lo*) is predictable based on the structure of the noun's initial onset. Davis' data is describable as follows: obstruent plus sonorant sequences select for *il*, while all /s/-sequences select for *lo*.[7] Sample data illustrating the distribution of *il* and *lo* are given in (47) and (48).

[7] Affricates additionally take *lo*.

(47) Consonant sequences that take *il*:

il blocco	the block
il braccio	the arm
il clima	the climate
il cratere	the crater
il drago	the dragon
il flutto	the surge
il frutteto	the orchard
il globo	the globe
il grado	the grade
il plotone	the platoon
il premio	the prize
il traffico	the traffic
il pneumatico	the tire

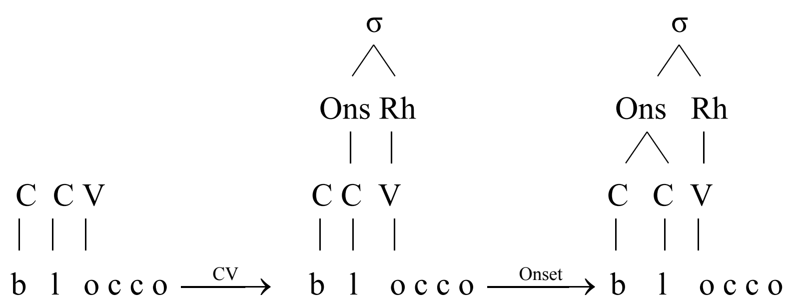
(48) Consonant sequences that take *lo*:

lo spirito	the spirit
lo sbaglio	the mistake
lo studente	the student
lo sfarzo	the pomp
lo svedese	the Swedish
lo scampo	the rescue
lo sgorbio	the blot
lo slancio	the outburst
lo smalto	the pavement
lo snob	the snob

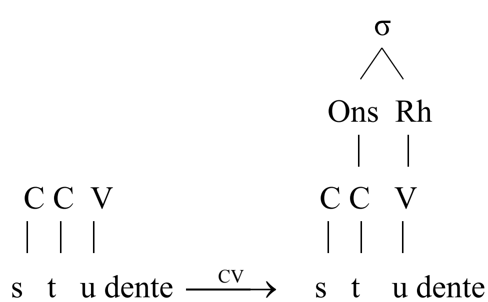
According to Davis, the crucial difference between the items in (47) and (48) is structural. The initial CC sequence in the nouns in (47) is parsed into a conventional complex onset. In the items in (48) however, /s/ is stray and the second member of the CC cluster occurs under the onset node—as per Steriade's (1988) analysis. This difference in structural representation feeds the rules that select the masculine definite article. Essentially, Davis stipulates that initial clusters beginning with a stray take *lo*, while all other consonant sequences take *il*.

Davis builds up the structural difference between (47) and (48) by making use of the same syllabification algorithm developed in Steriade (1982), and reviewed above in §2. Based on the CV Rule and the Onset Rule, the partial syllabifications given in (49) obtain:

(49) a.



(49) b.



In both (49a) and (49b), the CV Rule incorporates the first CV sequence in each word into a syllable. This leads to the application of the Onset Rule—but for (49a) only. Recall that application of the Onset Rule is dependent on whether the condition on MSD is met. In (49b), it is: /b/ and /l/ are far enough apart on Italian's sonority scale that the rule applies and /b/ is subsumed under the onset node. The same does not occur, however, for /s/ in *studente* because it is too close to /t/. The Onset Rule cannot execute. Consequently, /s/ is left stray.

The difference in structure between the items in (47) and (48) is directly attributable to Davis' formulation of the Italian MSD and sonority scale:

(50) Adjacent onset segments must have an MSD $\geq +4$.

(51) Italian sonority scale:

voiceless stops	voiced stops	noncoronal fricatives	coronal fricatives	n	m	liquids	vowels
1	2	3	4	5	6	7	8

Like Sanskrit, Italian enforces a rise in sonority within the onset constituent. The difference though, is that Italian is much pickier about the onset clusters it allows. Not only must sonority rise, but it must rise drastically—by at least 4 units (cf. Sanskrit's MSD of +1). Davis' analysis sanctions the /bl/ onset in *blocco* because it meets this strict criterion:

(52) $b_1 = 2$
$l_2 = 7$
$C_2 - C_1 \geq 4$
$7 - 2 = 5$

The /st/ cluster in *studente* does not though. Sonority actually falls in this case:

(53) $s_1 = 4$
$t_2 = 1$
$C_2 - C_1 \geq 4$
$1 - 4 = -3$

Since the MSD is not met by /st/, the Onset Rule cannot apply, and /s/ is left stray. The selection of *lo* follows as a direct, stipulated consequence of this structural characteristic for all items in (48). Note that this same outcome obtains for /s/ + sonorant clusters, contrary to what we observed in Sanskrit, where /s/ in these cases was able to syllabify as part of the onset:

(54) *smalto*

$s_1 = 4$
$m_2 = 6$
$C_2 - C_1 \geq 4$
$6 - 4 = 2$

4.1 An Alternative Analysis

Contrary to Davis, I contend that there is no *a priori* reason to assume that /s/-clusters differ from other consonant sequences structurally. Whereas the evidence in (47) and (48) motivates the need for *some* means of explaining the different behaviors of the two cluster types, it does not imply that this explanation must come in terms of a difference in structural representation. In an OT analysis of the same data set, McCrary (2002) shows that COMP-CODA and a markedness constraint against tautosyllabic sibilant plus consonant sequences is also able to account for the distribution of *il* and *lo*. The constraint set used in McCrary's analysis is given below:

(55) McCrary's constraint set:

Constraint	**Requirements**
*SC	No tautosyllabic sibilant-consonant clusters
*COMP(LEX)-CODA	No complex codas
ALIGN-LEFT(wd, σ)	The left edge of a word must be aligned with the left edge of a syllable
**lo*	*il* is the default allomorph; don't use *lo*

The constraint **lo* is obviously not a strong candidate for a linguistic universal. Consider its use here to be a shorthand method for noting that *il* is the preferred form of the masculine definite article. In what follows, I summarize McCrary's analysis. Because she does not consider candidates that include stray segments, I additionally include PARSE, an independently motivated constraint that requires exhaustive parsing of an input string into syllables. The significant effect of PARSE will be to militate against the unsyllabified strays proposed in Davis' account. Stipulating that exhaustive syllabic parsing is universal—i.e. that GEN does not create candidates containing unparsed segments—would also ensure that strays never surface. That possibility is rejected here in favor of an approach that gives the structures that Davis advocates a better chance of winning.

Two arguments for the positioning of *SC in the ranking hierarchy are given in (56).

(56)

/DEF + studente/	*SC	ALIGN-L(wd, σ)	**lo*
☞ a. los.tudente		*	*
b. il.studente	*!		

By taking the unmarked article *il* and syllabifying its /st/ cluster tautosyllabically, candidate (56b) actually fares better than (56a) on two constraints: **lo* and ALIGN-L. But (56b)'s relative unmarkedness under these two constraints is overridden by *SC. (56a) evaluates as optimal because it parses /st/ heterosyllabically and satisfies the higher-ranked constraint. Unfortunately, the ranking in (56) cannot on its own explain the distribution of *il* and *lo*. If high-ranked *SC disprefers tautosyllabic sibilant + consonant clusters, then why is it that *ils.tudente* fails to surface as optimal? The answer to this question is shown in (57):

(57)

/DEF + studente/	*COMP-CODA	**lo*
☞ a. los.tudente		*
b. ils.tudente	*!	

Both (57a) and (57b) offer the necessary heterosyllabic parses. One side-effect of this operation for (57b) is the creation of a complex coda. (57b) fails to be selected as optimal because it chooses to take the unmarked allomorph *il*, at the expense of violating a constraint on syllabic markedness. (56) and (57) together indicate the basic reason that sibilant + consonant sequences take *lo* rather than *il*—the only option given high-ranked *SC and *COMP-CODA is to select *lo* and parse the /s/ of the following cluster into a simple coda: e.g. *los.tudente*.

This elegant solution is complicated by the possibility raised by Davis that initial /s/ in the nouns in (48) may not be a part of any syllable. If /s/ is not syllabified, then a candidate like *il[s]tudente*—where [s] indicates a stray—would erroneously be evaluated as optimal:

(58)

/DEF + studente/	*COMP-CODA	*SC	ALIGN-L(wd, σ)	**lo*
☞ a. los.tudente			*	*!
☹ b. il[s]tudente			*	

The consonant /s/, which would normally syllabify as part of an SC onset or complex coda—both marked structures—avoids syllabification altogether, and ends up beating (58a) due to favorable evaluation by **lo*. In order to prevent such an outcome, PARSE must be included in the ranking:

(59)

/DEF + studente/	PARSE	**lo*
☞ a. los.tudente		*
b. il[s]tudente	*!	

Now *ils[s]tudente* is eliminated via a fatal violation of PARSE, even though it takes the default article, *il*. The ranking argument presented in (59) indicates that PARSE belongs in the same stratum as *COMP-CODA and *SC. Summary tableaux illustrating the complete analysis for the items in both (47) and (48) follow:

(60)

/DEF + studente/	*COMP-CODA	PARSE	*SC	ALIGN-L(wd, σ)	**lo*
a. il.studente			*!		
b. ils.tudente	*!			*	
c. il[s]tudente		*!		*	
d. lo.studente			*!		*
☞ e. los.tudente				*	*

(61)

/DEF + blocco/	*COMP-CODA	PARSE	*SC	ALIGN-L(wd, σ)	**lo*
☞ a. il.blocco					
b. ilb.locco	*!			*	
c. il[b]locco		*!		*	
d. lo.blocco					*!
e. lob.locco				*!	*!

The (a) candidates in (60-61) represent attempts to select for the default, unmarked version of the definite masculine article while simultaneously parsing the first two consonants of the noun tautosyllabically. In (61a), this tactic succeeds marvelously because stop + liquid onset sequences are impervious to *SC. The /st/ onset in (60a), however, is not. It is consequently eliminated. In a slight variation on the (a) candidates, (60b) and (61b) attempt heterosyllabic parses using the same allomorph. In both cases, this results in fatal violation of *COMP-CODA. As noted above, a violation of this sort can be circumvented by leaving what would have been the second element in a complex coda unsyllabified. This is the method attempted by the (c) candidates, which are eliminated by PARSE. The (d) candidates select for the *lo* version of the definite article, and parse the initial consonant sequence of the noun tautosyllabically. Doing so leaves (60d) with a fatal violation of *SC. (61d) is eliminated by **lo* for not selecting the default allomorph. Finally, the (d) candidates illustrate heterosyllabic parses combined with *lo*. (61e), while unmarked with respect to the higher-ranked constraints, fails due to violation of ALIGN-L and **lo*. Candidate (60e), on the other hand, evaluates as optimal. It violates the same constraints as (61e), but for nouns beginning with sibilant + consonant sequences, this is still the most harmonic option available.

The analysis summarized in (60-61) is superior to Davis' (1990) account in a number of ways. Recall that Davis explains the distribution of *il* and *lo* by (i) positing a structural distinction between the items in (47) and those in (48), and (ii) stipulating that selection of an allomorph is based on this structural distinction. His approach is able to provide a descriptive treatment of the data, but it lacks explanatory power. Why is it that nouns beginning with a stray consonant select for *lo*? Why doesn't a stray choose *il* instead? Davis fails to provide answers to these questions. On McCrary's account however, we have answers: the selection of *lo* represents the best available option for satisfying conditions that Italian imposes on what constitutes a legal onset or coda. An additional advantage that accrues under McCrary's analysis is that the structural distinction that Davis proposes becomes unnecessary. Sibilant + consonant sequences *end up* with heterosyllabic parses when combined with the definite article, and other clusters *end up* with tautosyllabic representations, but there is no evidence that suggests that an *a priori* structural distinction is required in order to get these details straight.

In fact, when we go a step further than McCrary does in her work, and consider how the nouns in (47) and (48) are evaluated without their articles, it becomes apparent that a structural distinction is impossible to maintain:

(62)

/blocco/	*COMP-CODA	PARSE	*SC	ALIGN-L(wd, σ)	*lo
☞ a. blocco					
b. [b]locco		*!		*	

The initial /b/ in blocco cannot be left unsyllabified—doing so incurs a fatal violation of PARSE. The optimal candidate—(62a)—parses /b/ as a member of a complex onset. Crucially, the same structure must be assigned to underlying /studente/ in (63):

(63)

/studente/	*COMP-CODA	PARSE	*SC	ALIGN-L(wd, σ)	*lo
☞ a. studente			*		
b. [s]tudente		*		*!	

Both (63a) and (63b) violate constraints in the first stratum. The competition between the two forms then continues on to the second stratum, where *[s]tudente* is eliminated by ALIGN-L. The grammar evaluates (63a) as optimal, and both cluster types—/s/- and non-/s/— are assigned identical onset structures.

A number of readers will no doubt note here that the tableau in (63) provides evidence for the ranking of PARSE over *SC. Enforcing this ranking would cause (63b) to fail due fatal violation of PARSE rather than ALIGN-L:

(64)

/studente/	*Comp-Coda	Parse	*SC	Align-L(wd, σ)	*lo
☞ a. studente			*		
b. [s]tudente		*!		*	

The important point here is that maintaining Parse >> *SC is not a prerequisite for making the correct prediction about which form is grammatical. Candidates like *[s]tudente* are evaluated as less than optimal by both Parse and Align-L, so either one of the rankings given in (63) and (64) achieves the right outcome. This result is significant because it illustrates just how difficult it is to develop an OT grammar that gives input strings consisting of a single word the structural representations that Davis proposes. The choice of a complex-onset candidate for all cluster-initial underlying forms is quite robust. It is guaranteed under at least two rankings, and will still obtain if Align-L is entirely eliminated from the ranking in (64). We are left to conclude that, contra Davis, all word-initial clusters are likely parsed in the same way, and that the initial stray—the structural innovation that purportedly explains why masculine nouns beginning with /s/-sequences take *lo*—is prohibited.

5 Conclusions

For each of the phenomena discussed in §1-3, we find that similar outcomes obtain. The acquisition of English initial clusters, Sanskrit perfective reduplication, and the distribution of *il* and *lo* in Italian are all best analyzed in terms of parsing all consonant sequences in the same manner, rather than assigning different structural representations to groups of consonant sequences that show different behavioral patterns. In each case we find that, not only is a structurally syncretic analysis possible, but that such an account has advantages over approaches that posit multiple structures. Increased predictive accuracy, more explanatory power, and less stipulation all accrue simply by doing away with the structural distinctions proposed in past research. Table (65) summarizes these findings.

(65) Benefits of structural syncretism:

Domain	Structural Differentiation	Structural Syncretism
§1. The acquisition of English word-initial clusters.	• Generates incorrect predictions in Stage 2.	• Makes the correct predictions in all stages.
	• Difference in /s/ v. non-/s/ behavior maintained by a structural distinction *and* ADJ-/s/.	• Difference in /s/ v. non-/s/ behavior maintained solely by ADJ-/s/.
§2. Sanskrit perfective reduplication.	• Reduplicative pattern for /s/ + obstruent sequences relies on a structural distinction generated using an SSP-influenced syllabification algorithm.	• All perfective reduplication handled using a universal constraint ranking based on the SSP.
	• Reduplicative pattern for all other consonant sequences relies on a stipulation and an SSP-influenced syllabification algorithm.	
§3. The distribution of *il* and *lo* in Italian.	• /s/-clusters have a different structural representation. Items with this type of structure are stipulated to take *lo*.	• /s/-clusters take *lo* due to constraints on what constitutes a legal onset and coda in Italian.

In addition to the advantages summarized above, two learnability benefits result based on the all-complex-onset analyses advocated in this work. First, because structural syncretism abolishes the representational difference between cluster types posited by previous researchers, the hypothesis space that a learner must navigate is reduced. Under an analysis that allows multiple structures, each input string must be assigned to one structure or another. Deciding how to correctly divvy up strings in a situation like this is a task that uses up time and cognitive resources. When only one structure is possible, structure assignment becomes trivial. Secondly, the relative lack of abstraction inherent in the all-complex-onset analyses I present for English, Sanskrit and Italian is beneficial. The single syllable structure argued for in this paper groups all pre-vocal segments into a single constituent—the onset. While this analysis is somewhat abstract in the sense that onsets are not physically identifiable in a raw speech stream, it is still less so than the alternatives—parsing an initial segment as a stray, or as an adjunct. In these cases, two pre-vocal groups are posited: onset + stray, or onset + adjunct. This represents a somewhat greater level of abstraction away from the perceptual cues available to the learner, and consequently poses a more daunting learning task. Future research along these lines should seek to reduce the amount of unseen structure in the grammar to the bare minimum.

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Appendix

A.1 Barlow's Analysis

1.1 Constraint Set

Constraint	**Requirements**
*ADJ(UNCT)	No adjuncts
ADJ(UNCT)-/s/	Only /s/ is allowed in an adjunct
*COMP(LEX-ONSET)	No complex onsets
MAX	No deletion
*COR(ONAL)/#__	No word-initial coronal obstruents
*M(ARGIN)/SON(ORANT)	No sonorants in onsets
*M(ARGIN)/OBS(TRUENT)	No obstruents in onsets
IDENT(ITY)	Segments in IO correspondence have identical feature specifications

1.2 Stage 1

1.2.1 /s/-Clusters

/skai/	*COR	*COMP	ADJ-/s/	MAX	*M/SON	*M/OBS	IDENT	*ADJ
a. skai	*!	*				**		
b. sai	*!			*		*		
☞ c. kai				*		*		
d. s.kai	*!					*		*

1.2.2 Non-/s/ Clusters

/blo/	*COR	*COMP	ADJ-/s/	MAX	*M/SON	*M/OBS	IDENT	*ADJ
a. blo		*!			*	*		
☞b. bo				*		*		
c. lo				*	*!			
d. b.lo			*!		*			*

1.3 Stage 2

1.3.1 /s/-Clusters

/skai/	*COMP	ADJ-/s/	MAX	*M/SON	*M/OBS	IDENT	*COR	*ADJ
a. skai	*!				**		*	
b. sai			*!		*		*	
c. kai			*!		*			
☞d. s.kai					*		*	*

1.3.2 Non-/s/ Clusters

/blo/	*COMP	ADJ-/s/	MAX	*M/SON	*M/OBS	IDENT	*COR	*ADJ
a. blo	*!			*	*			
☞ b. bo			*		*			
c. lo			*	*!				
d. b.lo		*!		*				*

1.4 Stage 3

1.4.1 /s/-Clusters

/skai/	ADJ-/s/	MAX	*M/SON	*M/OBS	IDENT	*COMP	*COR	*ADJ
a. skai				**!		*	*	
b. sai		*!		*			*	
c. kai		*!		*				
☞d. s.kai				*			*	*

1.4.2 Non-/s/ Clusters

/blo/	ADJ-/s/	MAX	*M/SON	*M/OBS	IDENT	*COMP	*COR	*ADJ
☞a. blo			*	*		*		
b. bo		*!		*				
c. lo		*!	*					
d. b.lo	*!		*					*

A.2 Experiments 1 and 2

2.1 Constraint Set

Constraint	**Requirements**
*ADJ(UNCT)	No adjuncts
ADJ(UNCT)-/s/	Only /s/ is allowed in an adjunct
*COMP(LEX-ONSET)	No complex onsets
MAX	No deletion
*COR(ONAL)/#__	No word-initial coronal obstruents
*M(ARGIN)/SON(ORANT)	No sonorants in onsets
*M(ARGIN)/OBS(TRUENT)	No obstruents in onsets

2.2 Experiment 1

2.2.1 Violation Patterns

Type	Target	*Comp	*Adj	Adj-/s/	Max	*Cor	*M/Obs	*M/Son
P	buti						*	
R	widiŋ							*
T	tʌbi					*	*	
PR	blo	*		*			*	*
sR	s.no		*			*		*
sO	s.kai		*			*	*	
sOR	s.pwei	*	*			*	*	*

2.2.2 Stage 1 /s/-Clusters

/skai/	Adj-/s/	*Adj	*Comp	Max	*Cor	*M/Son	*M/Obs
a. skai			*!		*		**
b. sai				*	*!		*
☞ c. kai				*			*
d. s.kai		*!			*		*

2.2.3 Stage 1 Non-/s/ Clusters

/blo/	Adj-/s/	*Adj	*Comp	Max	*Cor	*M/Son	*M/Obs
a. blo			*!			*	*
☞ b. bo				*			*
c. lo				*		*!	
d. b.lo	*!	*				*	

2.2.4 Stage 2 /s/-Clusters

/skai/	Adj-/s/	*Adj	*Comp	Max	*Cor	*M/Son	*M/Obs
☞ a. skai			*!		*		**
b. sai				*	*!		*
☹ c. kai				*			*
d. s.kai		*!			*		*

2.2.5 Stage 2 Non-/s/ Clusters

/blo/	Adj-/s/	*Adj	*Comp	Max	*Cor	*M/Son	*M/Obs
a. blo			*!			*	*
☞ b. bo				*			*
c. lo				*		*!	
d. b.lo	*!	*				*	

2.2.6 Stage 3 /s/-Clusters

/skai/	ADJ-/s/	MAX	*COMP	*ADJ	*COR	*M/OBS	*M/SON
a. skai			*!		*	**	
b. sai		*!			*	*	
c. kai		*!				*	
☞ d. s.kai				*	*	*	

2.2.7 Stage 3 Non-/s/ Clusters

/blo/	ADJ-/s/	MAX	*COMP	*ADJ	*COR	*M/OBS	*M/SON
☞ a. blo			*			*	*
b. bo		*!				*	
c. lo		*!					*!
d. b.lo	*!			*			*

2.3 Experiment 2

2.3.1 Violation Patterns

Type	Target	*COMP	*ADJ	ADJ-/s/	MAX	*COR	*M/OBS	*M/SON
P	buti						*	
R	widiŋ							*
T	tʌbi					*	*	
PR	b.lo		*	*				*
sR	s.no		*			*		*
sO	s.kai		*			*	*	
sOR	s.pwei	*	*			*	*	*

2.3.2 Stage 1 /s/-Clusters

/skai/	*COMP	ADJ-/s/	*ADJ	MAX	*COR	*M/SON	*M/OBS
a. skai	*!				*		**
b. sai				*	*!		*
☞ c. kai				*			*
d. s.kai			*!		*		*

2.3.3 Stage 1 Non-/s/ Clusters

/blo/	*COMP	ADJ-/s/	*ADJ	MAX	*COR	*M/SON	*M/OBS
a. blo	*!					*	*
☞ b. bo				*			*
c. lo				*		*!	
d. b.lo		*!	*			*	

2.3.4 Stage 2 /s/-Clusters

/skai/	*COMP	ADJ-/s/	MAX	*ADJ	*COR	*M/SON	*M/OBS
a. skai	*!				*		**
b. sai			*!		*		*
c. kai			*!				*
☞ d. s.kai				*	*		*

2.3.5 Stage 2 Non-/s/ Clusters

/blo/	*COMP	ADJ-/s/	MAX	*ADJ	*COR	*M/SON	*M/OBS
a. blo	*!					*	*
☞ b. bo			*				*
c. lo			*			*!	
d. b.lo		*!		*		*	

2.3.6 Stage 3 /s/-Clusters

/skai/	MAX	*COMP	ADJ-/s/	*COR	*M/OBS	*ADJ	*M/SON
a. skai		*!		*	**		
b. sai	*!			*	*		
c. kai	*!				*		
☞ d. s.kai				*	*	*	

2.3.7 Stage 3 Non-/s/ Clusters

/blo/	MAX	*COMP	ADJ-/s/	*COR	*M/OBS	*ADJ	*M/SON
a. blo		*!			*		*
b. bo	*!				*		
c. lo	*!						*
☞ d. b.lo			*			*	*

A.3 Experiment 3

3.1 Constraint Set

Constraint	**Requirements**
*COMP(LEX-ONSET)	No complex onsets
COMP(LEX-ONSET)-/s/	Only /s/ is allowed in the first position of a complex onset
*CCC	No three-place complex onsets
MAX	No deletion
*COR(ONAL)/#__	No word-initial coronal obstruents
*M(ARGIN)/SON(ORANT)	No sonorants in onsets
*M(ARGIN)/OBS(TRUENT)	No obstruents in onsets

/S/-clusters

3.2 Violation Patterns

Type	Target	*CCC	*COMP	COMP-/s/	MAX	*COR	*M/OBS	*M/SON
P	buti						*	
R	widiŋ							*
T	tʌbi					*	*	
PR	blo		*	*			*	*
sR	sno		*			*	*	*
sO	skai		*			*	**	
sOR	spwei	*	*			*	**	*

3.2 Stage 1

3.2.1 /s/-Clusters

/skai/	*CCC	COMP-/s/	*COMP	MAX	*COR	*M/SON	*M/OBS
a. skai			*!		*		**
b. sai				*	*!		*
☞ c. kai				*			*

3.2.2 Non-/s/ Clusters

/blo/	*CCC	COMP-/s/	*COMP	MAX	*COR	*M/SON	*M/OBS
a. blo	*!					*	*
☞ b. bo				*			*
c. lo				*		*!	

3.3 Stage 2

3.3.1 /s/-Clusters

/skai/	*CCC	COMP-/s/	MAX	*COMP	*COR	*M/SON	*M/OBS
☞ a. skai				*	*		**
b. sai			*!		*		*
c. kai			*!				*

3.3.2 Non-/s/ Clusters

/blo/	*CCC	COMP-/s/	MAX	*COMP	*COR	*M/SON	*M/OBS
a. blo		*!				*	*
☞ b. bo			*				*
c. lo			*			*!	

3.4 Stage 3

3.4.1 /s/-Clusters

/skai/	MAX	*CCC	COMP-/s/	*COMP	*COR	*M/SON	*M/OBS
☞ a. skai				*	*		**
b. sai	*!				*		*
c. kai	*!						*

3.4.2 Non-/s/ Clusters

/blo/	MAX	*CCC	COMP-/s/	*COMP	*COR	*M/SON	*M/OBS
a. blo			*			*	*
☞ b. bo	*!						*
c. lo	*!					*	

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