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The structure of /s/-sequences: evidence from a disordered system*

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ABSTRACT

This study considers the much-debated markedness and structural status of word-initial /s/-sequences in English by examining the development of KR (male, age 3;6) who has a phonological disorder. Three points in time are discussed: (1) when all initial consonant sequences are reduced to singletons; (2) when only initial /s/-sequences surface correctly; and (3) when all initial consonant sequences surface correctly. While these production patterns are common across developing systems, few accounts have addressed them in terms of structure or markedness. Toward that end, it is argued that KR's /s/-sequences surface as ADJUNCTS, rather than complex onsets. This is explained within optimality theory, whereby high-ranking markedness constraints prevent complex onsets but not adjuncts. The account offers an explanation for consonant sequence asymmetries within and across grammars, allowing for differing representations for /s/-sequences across speakers and for variation exhibited in children's productions. A typology of possible grammars is therefore offered, and clinical implications are considered.

INTRODUCTION

A common problem in phonological theory is accounting for word-initial consonant sequences in English, particularly the /s/-sequences (e.g. Selkirk, 1982; Treiman, Gross & Cwikiel-Glavin, 1992; Kenstowicz, 1994; Sherer,

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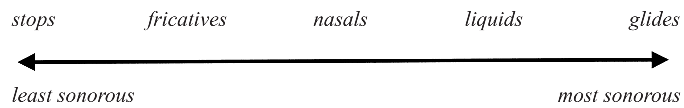

Fig. 1. Generic sonority hierarchy (adapted from Clements, 1990).

1994; Barlow, 1997; Gierut, 1999).[1] Accounting for the acquisition of consonant sequences, especially the /s/-sequences, is likewise problematic. The problems in both domains relate to issues of markedness, sonority sequencing, and order of acquisition facts. This paper addresses the status and structure of the /s/-sequences by examining the productions of one child with a phonological disorder. It will be shown, based on differential production patterns exhibited by this child, that /s/-sequences are represented as structurally different from other types of consonant sequences. The findings will also provide support for a possible typology of grammars in terms of consonant sequence occurrence.

There are several factors that contribute to the special status of /s/-sequences in English. First, while most consonant sequences in English follow the sonority sequencing principle shown in (1), certain word-initial /s/-sequences – those being the /s/ + stop sequences, such as in the word *state* – violate this principle. These particular sequences begin with a relatively more sonorous fricative segment and end with a relatively less sonorous stop segment. (See Figure 1.) Second, a phonotactic constraint against homorganic word-initial consonant sequences in English, such as homorganic labial */pw-/, */bw-/, and */fw-/, and homorganic alveolar */tl-/ and */dl-/, is violated by the allowable consonant sequences /st-/, /sl-/, and /sn-/. Third, /s/ is the only consonant that may be followed by a nasal or a stop, as in /sm-/, /sn-/, and /st-/; no other consonant may be followed by nasal or oral stops. Fourth, the only three-element consonant sequences that occur in English are those that begin with /s/ and are followed by allowable two-element sequences, as in /spl-/, /str-/, and /skw-/.

(1) Sonority sequencing principle: onsets must rise in sonority and codas must fall in sonority.

This difficulty in accounting for /s/-sequences also leads to problems with determining their relative markedness. Are /s/-sequences marked or unmarked?

A variety of factors determine the marked and unmarked aspects of language. One such factor that is typically appealed to is the sonority distance

[1] Wherever necessary, the generic cover term 'consonant sequence' will be used throughout to avoid the theoretical implications and ambiguity that might result following use of the term 'consonant cluster.' Specifically, it will be necessary to distinguish between two types of consonant sequences: those that form true clusters (complex onsets), and those that form adjuncts.

between the sound classes on the sonority scale shown in Figure 1, where unmarkedness corresponds to larger sonority distance. Accordingly, those /s/-sequences with a small sonority distance such as /sn-/ or /sm-/, or even those with a negative sonority distance such as /st-/ or /sp-/, would be considered relatively marked, while those with a larger sonority distance, such as /sw-/, would be considered relatively unmarked. Despite their differences in sonority distance, the /s/-sequences as a class seem to pattern independently of their relative markedness, particularly in acquisition.

Order of acquisition is another factor that determines markedness. Developmental norms studies have shown, for example, that consonant+glide sequences emerge before consonant+liquid sequences in first language acquisition (Smit, Hand, Freilinger, Bernthal & Bird, 1990; Smit, 1993). This implicational relationship was put to experimental test in treatment of children with phonological disorders, where the treatment of more marked sequences (those with smaller sonority distance) enhanced production of untreated, less marked sequences, but not *vice versa* (Elbert, Dinnsen & Powell, 1984; Gierut, 1999). Interestingly, many acquisition accounts do not address the /s/-sequences in terms of their markedness relative to other sequences. While both normative and case studies show evidence of /s/-sequences as a group being acquired later than other types of consonant sequences, there are studies that provide evidence of these sequences emerging earlier than other sequence types as well (Smit *et al.*, 1990; Smit, 1993; Gierut, 1999). In fact, there are several documented cases where /s/-sequences are produced prior to the emergence of any other presumably less-marked sequences (e.g. Gierut, 1999; see also Fikkert, 1994 for an account of cluster acquisition in Dutch). The /s/-sequences must therefore be treated as exceptional; however, the way in which they are assumed to be exceptional has yet to be agreed upon.

The /s/+stop and /s/+nasal sequences are further problematic in the acquisition data, both normal and disordered. Specifically, children's reduction patterns for these sequences are often – but not always – different from the typical pattern of reduction of obstruent+sonorant sequences (e.g. Ingram, 1989; Smit, 1993). That is, while most consonant sequences are reduced to the least sonorous singleton, for /s/-sequences the /s/ is often deleted from the target sequence, regardless of whether it is the least or most sonorous segment (Smit, 1993). Furthermore, whether or not /s/-sequences are produced in error is often independent of the production patterns for other sequences.

Another means for determining markedness is the consideration of language typologies. Those consonant sequences that occur in some languages but not others would be considered marked relative to those consonant sequences that occur in all languages that allow consonant sequences. Unsurprisingly, there are languages that have initial consonant sequences but not initial /s/-sequences, such as Spanish (Harris, 1969). There are also some languages that have only /s/- (or /ʃ/- or /ɬ/-) sequences: Acoma has initial /s/-sequences only (Miller, 1965); Mazateco has initial /s/- and /ʃ/-sequences only (Steriade, 1994; Blevins, 1995); and Haida has initial /s/- and /ɬ/-sequences only (Steriade, 1994). Other languages with similar consonant sequence inventories are Havasupai and Yuchi (Steriade, 1994). Steriade (1994) observes that languages can have either /s/ (or /ʃ/)+stop sequences or stop+liquid sequences, or both or neither. Indeed, most of the languages just referred to have consonant sequence inventories limited to fricative+stop sequences; however, Acoma, for example, has /s/+stop, /s/+glide, and /s/+affricate sequences.

Whether or not /s/-sequences and non-/s/-sequences are structurally equivalent continues to be debated in the literature. Many accounts assume that the /s/-sequences are structurally different from other consonant sequences. For example, a common explanation for the /s/-sequences (and certain other language-specific problematic consonant sequences) is that they surface with [s] as an ADJUNCT to the word-initial syllable (that is, [s] is extrasyllabic or extraprosodic). Compare Figure 2a and Figure 2b below.

In Figure 2a, the syllable structure of the word *plate* is organized with /pl-

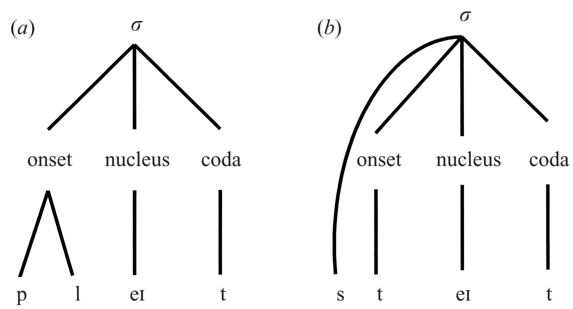

Fig. 2 (a) Subsyllabic structure of true cluster with branching (complex) onset. (b) Subsyllabic structure of adjunct with nonbranching onset and [s] as direct dependent of the syllable.

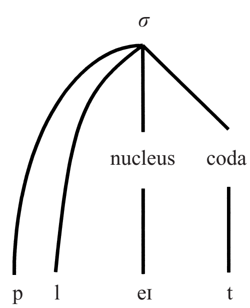

Fig. 3. Syllable-initial consonant sequence as direct dependent of syllable.

/ as a branching onset. In Figure 2b, the structure of the word *state* is organized such that the /st-/ does not form a branching onset; rather, the /t/ is the sole dependent of the onset constituent and /s/ is a direct dependent of the syllable.[2] This latter representational structure has been suggested for the /s/-sequences in English (Kenstowicz, 1994), as well as in Dutch (Fikkert, 1994), Italian (Davis, 1990), Sanskrit, Gothic, and Ancient Greek (Steriade, 1988). This is further supported by the fact that such a structure allows for the three element consonant sequences in English, such as /skw-/, /str-/, and /spl-/, which would be analysed as a sequence of an adjunct /s/ followed by a complex onset.

Typically, for English, it is only the /s/+stop sequences that are assumed to have this adjunct status, while all other consonant sequences are analysed as 'true clusters' or complex onsets. However, as already demonstrated, even the /s/+nasal and /sl-/ sequences are problematic, despite their conformity to the sonority sequencing principle. Evidence from other languages suggests that these /s/+sonorant sequences may pattern as adjuncts as well. For instance, consider the Italian data in (2) below:

(2) Distribution of *il* and *lo* in Italian (Davis, 1990, p. 45)

a. Forms that *il* precedes

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 traffico	'the traffic'	il pneumatico	'the tire'

b. Forms that *lo* precedes

lo spirito	'the spirit'	lo sbaglio	'the mistake'
lo studente	'the student'	lo sdentato	'the toothless'
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'	lo psicologo	'the psychologist'
lo xilofono	'the xylophone'	lo gnomo	'the gnome'

In Italian, all words that begin with /s/+stop, /s/+nasal, and /sl-/ sequences (in addition to certain other non-/s/-sequences) pattern similarly in that they take the *lo* form of the masculine definite article (Davis, 1990), while all other sequences take *il*. This patterning is especially interesting considering /fl-/ takes the *il* form and /sl-/ take the *lo* form, yet the two sequences are segmentally similar. According to Davis (1990), the asymmetry

[2] Other accounts have proposed that the adjunct is a degenerate syllable or an onset to a syllable without a vowel (Sherer, 1994).

is due to the fact that the *lo* forms constitute adjuncts, while the *il* forms constitute allowable complex onsets or true clusters.

Other languages show similar asymmetries. In Ancient Greek, /s/+stop and /s/+nasal sequences pattern differently from other consonant sequences in reduplication (Steriade, 1988; Kenstowicz, 1994). In addition, both of these languages and others (e.g. Klamath, according to Blevins, 1995) appear to treat other non-/s/-sequences as extrasyllabic.

Experimental evidence provides further support for the different representational structure of the /s/-sequences in English. For example, in Treiman *et al.*'s (1992) experimental study of syllabification of English real words and nonwords, subjects syllabified non-/s/ obstruent+sonorant sequences tautosyllabically, while the /s/-sequences – both /s/+stop and /s/+sonorant – were divided across syllable boundaries. Interestingly, an earlier study by Stemberger & Treiman (1986) found that there was not a statistically significant difference between the way English speakers treat the /s/-sequences versus obstruent+sonorant sequences, suggesting that there may be some variation across speakers. Clearly, there is a need for more research in this area.

In a study involving children with phonological disorders, Gierut (1999) compared treatment on marked obstruent+sonorant sequences with treatment on /s/+stop sequences. It was determined that training on obstruent+sonorant sequences with a small sonority distance resulted in across-class change such that many consonant sequences of varying sonority distance emerged. Conversely, treatment on /s/+stop sequences – also with a small sonority distance – resulted in within-class learning only, such that generalization was for the most part limited to other /s/-sequences. This is additional evidence in support of the differential representation of /s/-sequences.

Despite the overwhelming amount of evidence that /s/-sequences pattern differently from other consonant sequences, some have argued that they are not structurally different (see Blevins (1995) and references therein). For example, Blevins (1995) assumes that syllables do not have onset constituents *per se*; instead, all prevocalic segments of a syllable are immediately dominated by the syllable node, as in Figure 3.[3] The figure shows how *plate* would be represented. The word *state* would be represented in the same fashion. This model of the syllable does not allow for /s/-sequences to be structurally differentiated from other consonant sequences.

The absence of an onset constituent is assumed by Blevins and others based on the supposed lack of positive evidence in support of the onset

[3] Blevins (1995) also assumes a different structure for segments of the nucleus and coda. This information is excluded for expository purposes.

behaving as a constituent. Returning back to the example of Italian, Davis (1990) argued that the two classes of clusters shown in (2) provided evidence for the onset as a constituent. Blevins (1995) suggests a derivational account for the Italian data by arguing that the class of consonant sequences in (2a) are syllabified, but that the initial consonant of the each sequence in (2b) remains unsyllabified until later in the derivation. Thus, no reference to the onset is necessary. Such an account, however, cannot explain the differential patterning of the /s/-sequences as compared to other sequences. If /s/-sequences are NOT structurally different, then what prevents them from occurring in a grammar such as Spanish? Likewise, what prevents other sequences from occurring in a grammar that allows only /s/-sequences, such as Acoma? Furthermore, how do we account for the acquisition data?

In the following paragraphs, the development of consonant sequences by one child (KR) with a phonological disorder will be examined in order to further consider the markedness status and structural representation of the /s/-sequences. KR's productions are asymmetrical with respect to the patterning of /s/-sequences and other consonant sequences. The production patterns exhibited by KR will be shown to be common across both normally developing and phonologically disordered systems (Ingram, 1989; Smit, 1993). However, few studies have addressed children's consonant sequence production patterns in terms of the structural representation or relative markedness of /s/-sequences. The present account aims to provide additional evidence toward that end, which will also allow for some new insight into how /s/-sequences in particular may be represented in fully developed systems and why noted asymmetries exist within and across languages as well as individual speakers.

The account will appeal to the constraint-based framework of optimality theory (Prince & Smolensky, 1993), specifically, correspondence theory (McCarthy & Prince, 1995). Optimality theory is especially powerful in allowing for surface asymmetries and variable productions patterns that are common to developing systems. The theory is furthermore well suited in accounting for change over time, as demonstrated in several other accounts of developing systems (e.g. Gnanadesikan, 1996; Barlow, 1997; Barlow & Dinnsen, 1998; Bernhardt & Stemberger, 1998).

The following section will first present the relevant background information on the subject of this study. Following that, a constraint-based account will be provided, detailing three different points in the development of consonant sequences by this child and highlighting the difference between /s/-sequences and other consonant sequences. The longitudinal nature of this account may provide insight into the differential patterning of the sequence types, and will also illustrate how conflicting constraints yield interacting error patterns and thus the seeming asymmetries in a child's productions. The paper will conclude by addressing the implications of the account relative to markedness facts, clinical implications, language typologies, and the variation that may occur within and across grammars.

CASE STUDY

Subject and method

KR (age 3;6 at speech sample 1) was drawn from an archival database of a study that investigated monolingual American English-speaking children with phonological disorders of a moderate to severe nature (Elbert, Dinnsen, Swartzlander & Chin, 1990). All children from this study exhibited a minimum of six sounds in error across three manner classes on the *Goldman–Fristoe Test of Articulation* (Goldman & Fristoe, 1986), and scored within normal limits on intelligence measures and hearing screening.

The database includes phonetic transcriptions of children's spontaneous utterances obtained from a 306-item probe (adapted from Gierut, 1985) that targeted all English consonants in all relevant contexts, including consonant sequences. Speech samples from KR were examined across time: pretreatment (age 3;6), posttreatment (age 3;11), and four months posttreatment (age 4;3) (referred to as speech samples 1, 2, and 3, respectively). Minimal pair treatment, as described in Elbert *et al.* (1990), was adopted to train KR on the singleton obstruents /θ/, /z/, and /d/ each in the word-initial position. As a result of treatment, KR exhibited within-class generalization among stops and fricatives (Gierut, 1999). Specifically, this change included the learning of singleton /s/, which is important in consideration of the /s/-sequences and KR's improvement on these sequences. Aside from this, the sounds chosen for treatment would not be attributed to any significant change in how other target consonant sequences were produced. While it has been determined that teaching consonant sequences improves singleton production, the reverse has not been found (Elbert *et al.*, 1984; Gierut, 1999).

The account

In this section we consider the longitudinal development of KR's /s/-sequences relative to other target consonant sequences of English. It will be apparent that there is an asymmetry in the production of the different consonant sequences across time.

Speech sample 1. Data from KR's first speech sample are listed in (3) below. At this point in time, most consonant sequences are reduced to the least sonorous obstruent singleton, which is a common reduction strategy among normal and disordered developing systems (Gnanadesikan, 1996; Barlow, 1997; Barlow & Dinnsen, 1998). Hence, /tw-/ is reduced to [t] as opposed to [w]. Likewise, the /sk-/ is reduced to [k]. An asymmetry becomes apparent, however, when the /s/+sonorant sequences are considered. For all of these sequences KR exhibits reduction to the more sonorous segment. That is, /sm-/ is reduced to [m], and /sw-/ to [w]. This pattern of reduction, although less common, has been noted to occur in both normal and disordered development (Smit, 1993; Barlow, 1997). While previous research has been able to account for the common reduction strategy to the least sonorous segment (e.g. Gnanadesikan, 1996), asymmetries such as the present one have yet to be addressed.

(3) KR (age 3;6), speech sample 1

a. Target obstruent + sonorant sequences

[tɪn]	'twin'	[kin]	'queen'
[kut˺]	'cute'	[fu]	'few'
[peɪ]	'pray'	[gʌm]	'drum'
[go]	'grow'	[fowiŋ]	'throwing'
[bo]	'blow'	[kaɪm]	'climb'
[gʌv]	'glove'	[faɪ]	'fly'

b. Target /s/-sequences

[wɪm]	'swim'	[lipiŋ]	'sleeping'
[mɛoɫ]	'smell'	[no]	'snow'
[pũ]	'spoon'	[kovi]	'stove (dimin.)'
[kaɪ]	'sky'	[kawi]	'starry'
[peɪ]	'spray'	[ka]	'straw'
[gu]	'screw'	[kʊə]	'squirrel'

c. Target singleton /s/

[gop]	'soap'	[gʌni]	'sunny'
[kiŋk]	'sink'	[gɔk]	'sock'
[aɪsi]	'icy'	[gɛsi]	'dressy'
[gæshapʊ]	'grasshopper'	[bʌsi]	'bus (dimin.)'
[jɛs]	'yes'	[bʌs]	'bus'
[feɪs]	'face'	[maʊs]	'mouse'

d. Target singleton /t/ and /d/

[kʌbi]	'tub (dimin.)'	[keɪoli]	'tail (dimin.)'
[tiʃi]	'teeth (dimin.)'	[tĩʔ]	'tent'
[itiŋ]	'eating'	[buti]	'bootie'
[laɪt˺]	'light'	[dæt˺]	'that'
[gas]	'dress'	[gʊ]	'door'
[gɛʃ]	'desk'	[dɪs]	'dish'
[widiŋ]	'reading'	[lædʊ]	'ladder'
[bɛd]	'bed'	[haɪd]	'hide'

There is another pattern to note in KR's productions at this first point in time, and this is his positional constraint against the occurrence of [s] word-initially (shown in (3c)). /s/ never occurred in word-initial position and was instead realized as a velar stop. /s/ did surface correctly in word-medial and word-final positions. Generally, word-initial coronal obstruents were produced in error. This child exhibited an unusual but optional substitution pattern in which coronal obstruents were realized as velar stops in the word-initial position for the first speech sample only, as in (3d).[4] This was an unstable pattern for all coronal obstruents.

Specifically, singleton coronal obstruents were targeted a total of 71 times in word-initial position. Of these, 29 (41 %) were produced as coronal obstruents (either as the target or some other coronal) and 37 (52 %) were produced as velar stops (while the remaining 7 % were realized as some other sound due to assimilation). Furthermore, this substitution pattern was unstable even for a given morpheme. Consider the following pairs: 'tail' [tɛə^{l}] ~ 'taily' [keɪoli] and 'dish' [dɪs] ~ [gɪsi]. Interestingly, target velars never alternated and were always produced appropriately.

This phenomenon of velar substitution, while rare, has been reported to occur in developing systems and is attributed to a child-specific default place of articulation (Bernhardt & Stoel-Gammon, 1996). Dorsal might have been the default place for KR's phonological system at some point in his development. KR's variable productions from speech sample 1, however, seem to reflect a transitional stage in his phonological system. Specifically what kind of change is occurring is unclear. Either the default place is changing, or target coronals are becoming specified as coronals. Linguistic implications for the possibility of dorsal as a default are certainly important, since it is generally assumed that coronal is cross-linguistically unmarked (Paradis & Prunet, 1991). This phenomenon is scarcely addressed in the literature (cf. Bernhardt & Stemberger, 1998); nevertheless, the issue is tangential to the present account of consonant sequence production patterns.

To account for KR's reduction of the obstruent + sonorant sequences of (3a) to the less sonorous segment, we incorporate the four constraints listed in (4), along with the ranking in (5). These four constraints, ranked as such, have been shown to be sufficient for accounting for this common reduction pattern across children's systems (e.g. Gnanadesikan, 1996; Barlow, 1997; Barlow & Dinnsen, 1998). The markedness constraint *COMPLEX (Prince & Smolensky, 1993) is undominated, since consonant sequences do not occur at the first point in time. This constraint, then, requires that output forms surface with singletons. *COMPLEX is in conflict with the faithfulness constraint MAX (McCarthy & Prince, 1995), which prohibits deletion. Which singleton segment may surface depends on the *M/SONORANT and *M/OBSTRUENT constraints (adapted from Prince & Smolensky, 1993). These markedness constraints prohibit sonorants and obstruents, respectively,

[4] Additionally, the replacement of /s/ with [g] is likely reflective of the optional aspiration pattern in this child's speech, as seen across singleton stops: e.g. [bɪg] *pig*, but [p^{h}ʊʃiŋ] *pushing*.

from occurring in margin (here, specifically the onset) of the syllable, which follows from the sonority hierarchy and the sonority sequencing principle. That is, the most optimal syllable will be one that shows a maximum rise in sonority from the margins towards the peak (Clements, 1990). By nature of the sonority hierarchy, *M/SONORANT is universally ranked higher than *M/OBSTRUENT, which means that a less sonorous segment (an obstruent) in the margin will always be the more harmonic output form. See Tableau 1.

(4) *COMPLEX: Avoid branching onsets (Prince & Smolensky, 1993).[5]
MAX: Preserve underlying (input) segments in the surface (output) form (McCarthy & Prince, 1995).[6]
*M/SONORANT: Sonorants may not be parsed in syllable margins (adapted from Prince & Smolensky, 1993); universally ranked higher than *M/OBSTRUENT.[7]
*M/OBSTRUENT: Obstruents may not be parsed in syllable margins

TABLEAU 1. *Speech sample 1: illustration of reduction to the less sonorous segment*

	*COMP	MAX	*M/SON	*M/OBS
'blow' /blo/				
a. blo	*!		*	*
☞ b. bo		*		*
c. lo		*	*!	
d. o		**!		
'snow' /sno/				
a. sno	*!		*	*
X b. so		*		*
c. no		*	*!	
d. o		**!		

[5] In response to the suggestion of an anonymous reviewer, alternative names will be provided for each constraint. *COMPLEX has been referred to as **NotComplex(Onset)** in Bernhardt & Stemberger (1998).

[6] Under their containment version of optimality theory, Prince & Smolensky (1993) refer to a similar constraint against deletion called PARSE. Bernhardt & Stemberger (1998) label the constraint **Survived**.

[7] In her consonant sequence reduction account, Gnanadesikan (1996) appeals to the family of constraints μ/Y, which is similar in function to the *M constraints. This is a family of markedness constraints also based on the sonority hierarchy whereby the constraint μ/Y

(adapted from Prince & Smolensky, 1993).

(5) Speech Sample 1, Preliminary Ranking: *COMP ≫ MAX ≫ *M/SON ≫ *M/OBS

Tableau 1 illustrates KR's typical reduction of the target sequence /bl-/ in *blow* whereby the less sonorous singleton segment [b] is the optimal output onset. The constraints *COMPLEX, MAX, *M/SONORANT, and *M/OBSTRUENT are listed across the top of the tableau indicating their ranking – that is, with *COMPLEX ranked highest and *M/OBSTRUENT ranked lowest. Possible output candidates are listed along the left-hand side of the tableau. Candidate (a), the faithful candidate, incurs a fatal violation (indicated by the '*!') of *COMPLEX because of the presence of the [bl-] sequence. Consequently, candidate (a) is disallowed by the grammar. This candidate incurs further violations of the other two constraints (indicated by the '*'), but these violations are trivial. Candidates (b), (c), and (d) are the next three possible candidates that are to be evaluated against the constraints. All three candidates violate MAX, since not all of the segments from the input surface in the output. However, candidate (d) incurs a fatal violation due to its two violations of the constraint. Candidate (c) loses out to (b) due to the violation of *M/SONORANT by the sonorant [l] in the onset. Since the onset [b] in candidate (b) incurs a violation of the lowest ranked constraint *M/OBSTRUENT, this violation is inconsequential, and candidate (b) is the most harmonic candidate. The manual indicator ('☞') to the left of candidate (b) illustrates that it is the optimal form – the form that KR actually produces.

This analysis of the reduction pattern that has been so often noted in the literature cannot, however, account for KR's productions of the /s/ +sonorant sequences. Note in Tableau 1 that the constraint ranking incorrectly predicts *[so] as the optimal output (indicated by '**X**') for *snow* in KR's grammar, when [no] is the actual form. This must be accounted for by incorporating a high-ranking phonotactic constraint against coronal obstruents in his grammar, abbreviated as *COR/#_ in (6) below:

(6) *COR/#_: Avoid coronal obstruents in word-initial position.

This constraint is responsible for the general pattern of the substitution of velars for coronals. Some may argue that it is '*ad hoc*.' However, it is clear that positional constraints exist across languages, and the need for such

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requires that each segment Y be assigned a mora in the output. In the present case, then, a sonorant would be a preferred moraic segment in comparison to an obstruent, and an obstruent would then be chosen as the more harmonic marginal segment.

Bernhardt & Stemberger's (1998) account is similar to that of Prince & Smolensky (1993) and Gnanadesikan (1996); however, the relevant constraints are referred to as constraints on co-occurrence: **Co-occurring(σ-Margin → +consonantal), Co-occurring(σ-Margin → -sonorant),** and **Co-occurring(σ-Margin → -continuant).**

constraints within optimality theoretic accounts are well-established in the literature, for example, *[ŋ and *VdV in McCarthy & Prince (1995). With *COR/#_ undominated, reduction can never result with /s/ as the optimal singleton obstruent.

The constraint *COR/#_ must be in conflict with a faithfulness constraint that requires that corresponding input and output segments be identical in terms of their featural makeup. This constraint, IDENT, listed in (7) below, will incur violations by those input coronals that are realized as velars. With *COR/#_ outranking IDENT, coronals may be realized as a velar stop in word-initial position, as in the word *soap* realized as [gop].

(7) IDENT: Corresponding input and output segments have identical feature specifications (McCarthy & Prince, 1995).

Why specifically velars (and not labials) substitute for coronals could be accounted for by appealing to a family of constraints against insertion (DEP; McCarthy & Prince, 1995), whereby insertion of the velar place feature is a less serious violation of the grammar than insertion of labial or coronal features: DEP/CORONAL, DEP/LABIAL ≫ DEP/DORSAL. This family of constraints would be ranked below both *COR/#_ and IDENT to yield the substitution pattern.

Because the pattern of substitution of velars for coronals is optional in KR's productions, this ranking between *COR/#_ and IDENT may be unstable, reflecting development in KR's phonological system. As phonological development is a gradual process, a theoretical explanation for this optionality is required. Some have proposed that equally ranking constraints can account for such variability (e.g. Tesar & Smolensky, 1998). Others have offered learning algorithms to allow for gradual change (e.g. Boersma, 1997). These learning algorithms are discussed further in the Discussion.

Because the velar substitution pattern is only marginally relevant to the discussion of consonant sequences, the ranking of *COR/#_ over IDENT is maintained, for the purposes of analysis here, as it reflects the slightly more prevalent production pattern of velars substituting for coronals in KR's phonology. Furthermore, the DEP family of constraints will not be considered further in the analysis in order to simplify the presentation of the account.

The revised ranking for KR's grammar at the first speech sample is shown in (8). An illustration of this ranking and how it accounts for KR's grammar is shown in Tableau 2 for the target words *blow*, *sky*, *snow*, *spray*, and *sunny*.

(8) Speech sample 1: *COR, *COMP ≫ MAX ≫ *M/SON ≫ *M/OBS ≫ IDENT

For each target consonant sequence, there is reduction to a singleton. The non-/s/-sequences are reduced to the obstruent, while the /s/-sequences are reduced to the second segment (whether an obstruent or a sonorant). Undominated *COR/#_ ensures that [s] will never surface. This forces

TABLEAU 2. *Speech sample 1 : all consonant sequences reduced to singletons*

	*COR	*COMP	MAX	*M/SON	*M/OBS	IDENT
'blow' /blo/						
a. blo		*!		*	*	
☞ b. bo			*		*	
c. lo			*	*!		
d. o			**!			
'sky' /skaɪ/						
a. skaɪ	*!	*			**	
b. saɪ	*!		*		*	
☞ c. kaɪ			*		*	
d. aɪ			**!			
'snow' /sno/						
a. sno	*!	*		*	*	
b. so	*!		*		*	
☞ c. no			*	*		
d. o			**!			
'spray' /spreɪ/						
a. spreɪ	*!	*		*	**	
b. speɪ	*!	*	*		**	
c. preɪ		*!	*	*	*	
☞ d. peɪ			**		*	
'sunny' /sʌni/						
a. sʌni	*!				*	
b. tʌni	*!				*	*
☞ c. gʌni					*	*
d. ʌni			*!			

singleton /s/ to be produced as [g], and also forces the second segment of a target /s/-sequence to surface. Undominated *COMPLEX requires that a complex onset will never surface. The universal ranking of the *M/SONORANT and *M/OBSTRUENT constraints ensure that the non-/s/-sequences are reduced to the obstruent. In sum, each reduction pattern is accounted for by appealing to the six constraints discussed above. However, upon examination of the data from the second speech sample, it will be apparent that the /s/-sequences pattern differently – which will not be due to *COR/#_, but rather to the special structural representation of the /s/-sequences.

Speech sample 2. At the time of the second speech sample, shown in (9) below, KR's positional constraint against coronals in word-initial position is no longer apparent (as in (9c) and (9d)). Consequently, he produces singleton /s/ correctly in all contexts. Furthermore, all target /s/-sequences are realized correctly (as in (9b)). This includes both /s/+stop sequences and all the /s/+sonorant sequences. However, a different asymmetry is apparent for this speech sample, because all other obstruent+sonorant sequences are still reduced to singletons (as in (9a)). Once again, each of those consonant sequences is reduced to the less sonorous segment of the target sequence. What is furthermore interesting is that all three-element sequences exhibit patterns of both types of sequences. That is, they are reduced to two-element sequences consisting of /s/+stop (as in (9b)).

(9) KR (age 3;11), speech sample 2

a. Target obstruent+sonorant sequences

[dɪn]	'twin'	[kin]	'queen'
[kut]	'cute'	[fu]	'few'
[peɪ]	'pray'	[dʌm]	'drum'
[go]	'grow'	[fowin]	'throwing'
[bo]	'blow'	[gaɪm]	'climb'
[gʌv]	'glove'	[faɪ]	'fly'

b. Target /s/-sequences

[swɪm]	'swim'	[slipin]	'sleeping'
[smeɪo]	'smell'	[sno]	'snow'
[spun]	'spoon'	[stovi]	'stove (dimin.)'
[skaɪ]	'sky'	[stawi]	'starry'
[speɪ]	'spray'	[stɔ]	'straw'
[sku]	'screw'	[skʊə]	'squirrel'

c. Target singleton /s/

[sop]	'soap'	[sʌni]	'sunny'
[sĩk]	'sink'	[sak]	'sock'
[aɪsi]	'icy'	[dusi]	'juicy'
[jɛs]	'yes'	[bʌs]	'bus'

d. Target singleton /t/ and /d/

[tʌbi]	'tub (dimin.)'	[tɛwi]	'tail (dimin.)'
[tisi]	'teeth (dimin.)'	[tɛn]	'tent'
[idin]	'eating'	[buti]	'bootie'
[laɪt]	'light'	[dæt]	'that'
[dɪʊ]	'deer'	[dɪwi]	'deer (dimin.)'
[dɪʃ]	'dish'	[dɛs]	'desk'
[widin]	'reading'	[lædʊ]	'ladder'
[bɛd]	'bed'	[haɪd]	'hide'

Because some consonant sequences still are reduced at this second point in time, it is evident that *COMPLEX still must be very highly ranked. However, since target singleton /s/ and /s/-sequences are surfacing correctly, *COR/#_ must be ranked rather low – lower than the IDENT constraint requiring featural faithfulness. Consider the possible ranking in (10) for this second point in time, which is illustrated in Tableau 3:

(10) Speech sample 2: *COMP ≫ MAX ≫ *M/SON ≫ *M/OBS ≫ IDENT ≫ ***COR**

While the ranking in (10) can account for the continued reduction of non-/s/-sequences (such as /bl-/ in *blow*) and the now correct production of singleton /s/ (as in *sunny*), a problem arises with accounting for the now correct occurrence of the /s/-sequences. High-ranking *COMPLEX prevents the occurrence of the /s/-sequences by incorrectly predicting reduced forms for the words *sky*, *snow*, and *spray*, creating an apparent ranking paradox.

Clearly, the /s/-sequences are patterning differently from the non-/s/-sequences, and so it is assumed that they form consonant sequences that have a structural representation that is different from the other possible sequences of the language. Since *COMPLEX prevents complex onsets from surfacing, but /s/-sequences surface correctly, then perhaps /s/-sequences do not form complex onsets in this child's grammar. It is therefore assumed that all the /s/-sequences in KR's grammar have the adjunct structural representation shown in Figure 2b. KR's grammar, then, allows for adjuncts but not complex onsets. As a result, we must appeal to additional constraints that relate to this type of structural representation, and these are listed in (11) below.

(11) *ADJUNCT: Adjuncts are prohibited (adapted from Sherer, 1994).
ADJUNCT-/s/: Only /s/ is licensed by the adjunct position (adapted from Sherer, 1994).

The markedness constraint *ADJUNCT prohibits adjuncts from surfacing. Like syllables with complex onsets, syllables with adjuncts are considered marked relative to syllables with singleton segments within the onset. The

TABLEAU 3. *Preliminary ranking for speech sample 2*

	*COMP	MAX	*M/SON	*M/OBS	IDENT	*COR
'blow' /blo/						
a. blo	*!		*	*		
☞ b. bo		*		*		
c. lo		*	*!			
d. o		**!				
'sky' /skaɪ/						
a. skaɪ	*!			**		*
b. saɪ		*		*		*!
X c. kaɪ		*		*		
d. aɪ		**!				
'snow' /sno/						
a. sno	*!		*	*		*
X b. so		*		*		*
c. no		*	*!			
d. o		**!				
'spray' /spreɪ/						
a. spreɪ	*!		*	**		*
b. speɪ	*!	*		**		*
c. preɪ	*!	*	*	*		
X d. peɪ		**		*		
'sunny' /sʌni/						
☞ a. sʌni				*		*
b. tʌni				*	*!	*
c. gʌni				*	*!	
d. ʌni		*!				

*ADJUNCT constraint was adapted from Sherer's (1994) *APPENDIX constraint in his account for extraprosodic segments in English and other languages. Sherer defines the appendix as the 'consonant that is dominated directly by the syllable node at the end of the syllable' (1994: 67). This definition is similar to that of the adjunct at the beginning of the word-initial syllable. For a grammar that disallows adjuncts, *ADJUNCT would be ranked very high; for a grammar that allows adjuncts, it would be ranked relatively low. In KR's grammar, *ADJUNCT must be ranked rather low in order to allow for the /s/-sequences to surface.

How, though, do we account for the fact that only /s/ – and no other segment – may surface as an adjunct in KR's grammar? In Sherer's (1994) account of word-final consonant sequence asymmetries, it was noted that, cross-linguistically, extraprosodic segments tend to be coronal and, more specifically, apical (Paradis & Prunet, 1991). Sherer proposed the universal constraint hierarchy shown in (12) to account for this asymmetry:

(12) Sherer's (1994) proposed ranking for extraprosodic segments

$*\text{APPENDIX}_{\text{NONCOR}}$:	Non-coronal appendix consonants are prohibited.
$*\text{APPENDIX}_{\text{NONAPIC}}$:	Non-apical coronal appendix consonants are prohibited.
$*\text{APPENDIX}_{\text{APICAL}}$:	Apical appendix consonants are prohibited.

The constraints in (12), ranked in that order, ensure that apical coronals /t/, /d/, /s/, and /z/ are the preferred segments in extraprosodic (adjunct) position. In the present case, however, only /s/ may be allowed in the initial adjunct position, which motivates adaptation and elaboration of Sherer's scale to include the following constraints in (13):

(13) Proposed ranking for initial adjunct segments

$*\text{ADJUNCT}_{\text{NONCOR}}$:	Non-coronal adjunct consonants are prohibited.
$*\text{ADJUNCT}_{\text{NONAPIC}}$:	Non-apical coronal adjunct consonants are prohibited.
$*\text{ADJUNCT}_{\text{APICAL}}$:	Apical adjunct consonants are prohibited.
$*\text{ADJUNCT}_{\text{NONCONT}}$:	Non-continuant adjunct consonants are prohibited.

To save space, this constraint may be abbreviated as an undominated licensing constraint, ADJUNCT-/s/, as in (11) above with the inherent ranking in (13). This abbreviated constraint family licenses only /s/ as a possible adjunct segment in word-initial position.[8] The revised ranking for KR's

[8] The fricative /z/ would not be expected to occur in adjunct position in KR's phonology for the same reason that it does not occur in adult English. No voiced fricatives occur in word-initial consonant sequences, regardless of their proposed representational structure. The exception would be the /vj-/ sequence, which is questionable as a consonant sequence (Davis & Hammond, 1995; Barlow, 1997).

TABLEAU 4. *Speech sample 2 : adjuncts are produced, complex onsets are reduced*

	*COMP	ADJ-/s/	MAX	*M/SON	*M/OBS	IDENT	*COR	*ADJ
'blow' /blo/								
a. blo	*!			*	*			
☞ b. bo			*		*			
c. lo			*	*!				
d. b.lo		*!		*				*
'sky' /skaɪ/								
a. skaɪ	*!				**		*	
b. saɪ			*!		*		*	
c. kaɪ			*!		*			
☞ d. s.kaɪ					*		*	*
'snow' /sno/								
a. sno	*!			*	*		*	
b. so			*!		*		*	
c. no			*!	*				
☞ d. s.no				*			*	*
'spray' /spreɪ/								
a. spreɪ	*!			*	**		*	
b. preɪ	*!		*	*	*			
☞ c. s.peɪ			*		*		*	*
d. s.preɪ	*!			*	*		*	*
'sunny' /sʌni/								
☞ a. sʌni					*		*	
b. tʌni					*	*!	*	
c. gʌni					*	*!		
d. ʌni			*!					

second speech sample is shown in (14) below. Tableau 4 shows how this new ranking in (14) can account for KR's productions of the words *blow*, *sky*, *snow*, *spray*, and *sunny* at the second speech sample, in which true clusters (complex onsets) are reduced to a singleton and singleton /s/ and adjuncts occur target-appropriately. A period is used to indicate a prosodic boundary, where elements to the left of the period are considered adjuncts. Note that candidate forms in which two segments from the target consonant sequence are absent are excluded from this and following tableaux in order to save space. In every case, multiple violations of MAX will always be fatal.

(14) Speech sample 2: *COMP, ADJ-/s/ ≫ MAX ≫ *M/SON ≫ *M/OBS ≫ IDENT ≫ ***COR**, *ADJ

Low-ranking *COR/#_ allows /s/ to surface at this point in time. With low ranking *ADJUNCT, adjuncts are allowed to occur. With *COMPLEX still undominated, complex onsets are prevented from surfacing, and reduction to the less sonorous segment occurs for non-/s/-sequences. These consonant sequences cannot occur as adjuncts due to the high-ranking ADJUNCT-/s/ constraint family that disprefers any segment other than /s/ as an adjunct. All /s/-sequences, on the other hand, are allowed to surface as adjuncts. In addition, the three-element sequences, while reduced, surface with adjunct structure, but not complex onset structure, and their surface forms are therefore entirely predictable from the current constraint ranking. Thus, the asymmetrical consonant sequence production pattern in speech sample 2 is accounted for.

Now that we have characterized the /s/-sequences as structurally different from other target sequences in KR's grammar, we may reconsider the facts of speech sample 1. Recall that we attributed the absence of /s/-sequences to high-ranking *COMPLEX, and the absence of initial /s/ to high-ranking *COR/#_. Even at the time of speech sample 1, *ADJUNCT was ranked very low. Thus, the absence of adjuncts at speech sample 1 was not due to the markedness constraint against adjunct structure; rather, their absence was due to the high ranking constraints *COR/#_ and ADJUNCT-/s/, which prohibit initial coronals and non-/s/ adjuncts, respectively. The revised ranking for the first speech sample is shown in (15) below, and the ranking is shown in Tableau 5.

(15) Speech sample 1, revised: *COR, *COMP, ADJ-/s/ ≫ MAX ≫ *M/SON ≫ *M/OBS ≫ IDENT ≫ *ADJ

Note that for both rankings in (14) and (15) *COMPLEX is ranked higher than *ADJUNCT. For both grammars *ADJUNCT is so low ranked that it is not active in the grammar. In fact, the real interaction for both points in time is that between *COMPLEX and *COR/#_. The interaction of these two constraints accounts for KR's differential error patterns at both points in time.

TABLEAU 5. *Speech sample 1, revised ranking*

	*COR	*COMP	ADJ-/s/	MAX	*M/SON	*M/OBS	IDENT	*ADJ
‘blow’ /blo/								
a. blo		*!			*	*		
☞ b. bo				*		*		
c. lo				*	*!			
d. b.lo			*!		*			*
‘sky’ /skaɪ/								
a. skaɪ	*!	*				**		
b. saɪ	*!			*		*		
☞ c. kaɪ				*		*		
d. s.kaɪ	*!					*		*
‘snow’ /sno/								
a. sno	*!	*			*	*		
b. so	*!			*		*		
☞ c. no				*	*			
d. s.no	*!				*			*
‘spray’ /spreɪ/								
a. spreɪ	*!	*			*	**		
b. preɪ		*!		*	*	*		
☞ c. peɪ				**		*		
d. s.peɪ	*!			*		*		*
e. s.preɪ	*!	*			*	*		*
‘sunny’ /sʌni/								
a. sʌni	*!					*		
b. tʌni	*!					*	*	
☞ c. gʌni						*	*	
d. ʌni				*!				

The ranking between *COMPLEX and ADJUNCT would also suggest that complex onsets, or true clusters, are marked relative to adjuncts, at least for KR's grammar. This markedness relationship will no longer be apparent in this child's grammar at the time of the third speech sample.

Speech sample 3. By the time of the third speech sample, KR produces all target consonant sequences correctly, as shown in (16) below.

(16) KR (age 4;3), speech sample 3

a. Target obstruent + sonorant sequences

[twɪn]	'twin'	[kwin]	'queen'
[fwu]	'few'	[pleɪ]	'play'
[klaɪm]	'climb'	[glʌv]	'glove'
[blo]	'blow'	[drɛs]	'dress'
[pweɪ]	'pray'	[fwowiŋ]	'throwing'
[bwʌs]	'brush'	[gwo]	'grow'

b. Target /s/-sequences

[swɪm]	'swimming'	[slipiŋ]	'sleeping'
[slip]	'sleep'	[sno]	'snow'
[spun]	'spoon'	[stov]	'stove'
[skaɪ]	'sky'	[spweɪ]	'spray'
[skwu]	'screw'	[stwɔ]	'straw'
[stwɔ]	'straw'	[skwə]	'squirrel'

c. Target singleton /s/

[sup]	'soup'	[sʌni]	'sunny'
[aɪsi]	'icy'	[dʒusi]	'juicy'
[jɛs]	'yes'	[bʌs]	'bus'

d. Target singleton /t/ and /d/

[tʌbi]	'tub (dimin.)'	[tɛɪli]	'tail (dimin.)'
[itiŋ]	'eating'	[buti]	'bootie'
[laɪt]	'light'	[ðæt]	'that'
[dʌk]	'duck'	[do]	'door'
[widiŋ]	'reading'	[lædʊ]	'ladder'
[waɪd˺]	'ride'	[wid]	'read'

KR's third speech sample shows evidence of another reranking of constraints. This time, all consonant sequences (true clusters, adjuncts and three-element sequences) are surfacing target-appropriately.[9] It is apparent that *COMPLEX is ranked much lower now, allowing for output forms that

[9] The exception is that obstruent + /r/ sequences are produced as obstruent + [w]. This substitution pattern is common among all developing systems and is consistent with that for singleton /r/ in KR's system. That is, /r/ in both singleton and consonant sequence contexts is produced as [w]. To account for this substitution pattern, the incorporation of an undominated inventory constraint, *R, would be necessary to prevent target /r/ from surfacing.

have branching onsets. The new ranking for the third speech sample is shown in (17) below, and is illustrated in Tableau 6 for the same words, *blow*, *sky*, *snow*, *spray*, and *sunny*:

(17) Speech sample 3: ADJ-/s/, MAX ≫ *M/SON ≫ *M/OBS ≫ IDENT ≫ ***COMP**, *COR, *ADJ

Our new constraint ranking allows for both types of sequences – adjuncts and true clusters – to occur at this third point in time. Lower-ranked *COMPLEX allows for a sequence such as /bl-/ in *blow* to surface correctly as a true cluster, while the ranking of *M/SONORANT and *M/OBSTRUENT over *COMPLEX prevents the /s/-sequences from surfacing as true clusters, and instead they surface as adjuncts. The ranking also allows for the three element sequences to surface with /s/ as an adjunct followed by a complex onset. As a result of the constraint demotion, violation of MAX is now fatal, and deletion of a segment is prevented. Hence, all words are surfacing target-appropriately in this third speech sample.

Note that in this final ranking *COMPLEX, *COR/#_, and *ADJUNCT are not crucially ranked relative to one another – that is, we have no independent evidence that shows a preference for one over the other. All three constraints may be violated in order to satisfy high-ranking MAX.

To summarize, three different points in time reflected three different stages of consonant sequence production in KR's phonological system. This was accounted for by three different constraint rankings for KR's grammar. In the following section, we consider clinical and theoretical implications of this account. Alternative analyses are also considered.

DISCUSSION

The goal of this paper was to present and account for a child's productions that showed an asymmetry with respect to the patterning of consonant sequences over three points in time. Specifically, the asymmetry related to target /s/-sequences versus other non-/s/-sequences, which have been characterized as adjuncts and true clusters respectively. While KR's production patterns (or the asymmetries therein) were not notably different from those of other normal or disordered systems, few accounts have addressed such patterns in terms of their markedness or structural status. The present account incorporated positional constraints as well as faithfulness and markedness constraints into an optimality theoretic framework. It was shown that the change in this child's productions could be accounted for by reranking these constraints over time. The specific constraints and their reranking over time are shown in (18) below.

(18) Speech sample 1: *COR, *COMP, ADJ-/s/ ≫ MAX ≫ *M/SON ≫ *M/OBS ≫ IDENT ≫ *ADJ

Speech sample 2: *COMP, ADJ-/s/ ≫ MAX ≫ *M/SON ≫ *M/OBS ≫ IDENT ≫ ***COR**, *ADJ
Speech sample 3: ADJ-/s/, MAX ≫ *M/SON ≫ *M/OBS ≫ IDENT ≫ ***COMP**,*COR, *ADJ

It is important to note that the adjuncts could have occurred correctly from the first point in time, if not for the high-ranking positional constraint *COR/#_. Once this constraint was demoted below the feature faithfulness constraint IDENT, the adjuncts were surfacing (as were word-initial singleton coronals). The true clusters, however, were prevented from occurring by the markedness constraint *COMPLEX, which prevented branching onsets. Only when this constraint was demoted could true clusters surface correctly.

It was argued that ALL /s/-sequences had this adjunct structural representation at the time of both the second and third speech samples. In other words, the grammar changed via a reranking of constraints, but the structural representation of the target sequences did not change. Furthermore, by the third speech sample, consonant sequences of all types were occurring correctly. This suggests, then, that this child has approximated the ambient system with a grammar that is somewhat different than what has been posited for English as a fully developed system. Specifically, the /s/+sonorant sequences – including /sl-/ and /sw-/ – are classed with the adjuncts in KR's system. This is not an assumption that is typically made for English consonant sequences; nevertheless, this account has shown that it is possible, given the appropriate constraint ranking. This suggests that other speakers of the language may have different structural representations for these consonant sequences as well. The status of /s/-sequences in the fully developed system has long been under debate, and no specific structural representation has been agreed upon. While many agree that /s/-sequences are adjuncts (e.g. Steriade, 1988; Davis, 1990; Kenstowicz, 1994), others assume they share the same structure as other consonant sequences (e.g. Blevins, 1995, and references therein). Still others assume the /s/-sequences have some other type of structure. (See next section.) Furthermore, children develop along very different paths – some with consonant sequence production patterns very similar to KR's, others with patterns that are very different.

Since it is possible (as demonstrated in this account and others) that a child's grammar may converge on the target grammar without changing the nature of the structural representations of these consonant sequences (see also Barlow, 1997), it is likewise possible that adult speakers of English may have variable structural representations for the /s/+sonorant sequences. Some adults may analyse these sequences as adjuncts, while others may not. What this suggests, then, is that there is no single grammar for English; rather, a variety of grammars may exist, each with differences that are subtle enough to go undetected in ordinary speech. (See below.)

TABLEAU 6. *Speech sample 3 : complex onsets and adjuncts are produced*

	ADJ-/s/	MAX	*M/SON	*M/OBS	IDENT	*COMP	*COR	*ADJ
'blow' /blo/								
a. blo			*	*		*		
☞ b. bo		*!		*				
c. lo		*!	*					
d. b.lo	*!		*					*
'sky' /skaɪ/								
a. skaɪ				**!		*	*	
b. saɪ		*!		*			*	
c. kaɪ		*!		*				
☞ d. s.kaɪ				*			*	*
'snow' /sno/								
a. sno			*	*!		*	*	
b. so		*!		*			*	
c. no		*!	*					
☞ d. s.no			*				*	*
'spray' /spreɪ/								
a. spreɪ			*	**!		*	*	
b. preɪ		*!	*	*		*		
c. s.peɪ		*!		*			*	*
☞ d. s.preɪ			*	*		*	*	*
'sunny' /sʌni/								
☞ a. sʌni				*			*	
b. tʌni				*	*!		*	
c. gʌni				*	*!			
d. ʌni		*!						

Alternative analyses

It should be noted that /s/-sequences have been analysed by some as *complex segments* rather than adjuncts for developing grammars (e.g. Barlow & Dinnsen, 1998), fully-developed English (e.g. Selkirk, 1982), and other languages (e.g. Kim, 1990). The structure of such proposed segments is similar to that of affricates, where the complex segment occupies a single skeletal point but branches into two different manner specifications ([± continuant]). This type of structural representation for the /s/-sequences may occur in other grammars; however, for KR it is not a likely analysis, due to the fact that affricates were not allowed word-initially in KR's grammar until the time of the third speech sample. At speech sample 1, word-initial /tʃ/ and /dʒ/ were produced as [k] and [g], respectively. At speech sample 2, they were produced as [t] and [d], respectively. At speech sample 3, they were produced target appropriately. Interestingly, there is evidence in the literature that suggests that complex onsets may only emerge once complex segments occur (e.g. Barlow, 1997; Gierut, 1999). A complex segment analysis for KR's /s/-sequences would not be consistent with such evidence, except at the third point in time. It is unlikely that the child's representations for the consonant sequences would have changed from adjuncts to complex segments over time.

Yet another possible analysis would be to assume that the asymmetry in consonant sequence production exhibited in KR's data is attributed to highly ranked sequence constraints as discussed in Bernhardt & Stemberger (1998). For example, one might posit that only /s/-sequences are allowed due to a high-ranking constraint that allows for only /s/ in C_1 position followed by any other sonorant or any voiceless stop in C_2 position, along the lines of their **NoSequence**$_{\textbf{Onset}}$ constraints. However, in order to be able to allow for the occurrence of /s/-sequences and the non-occurrence of ALL OTHER consonant sequences, the relevant constraint would have to be extremely specific, for example, **NoSequence**$_{\textbf{Onset}}$**(Non-/s/… + consonantal)**. Additionally, such a constraint has not been motivated elsewhere in the literature and does not speak to the general constraint against complex onsets or the possibility of an adjunct structural representation, both of which have been motivated independently for English and other languages.

Some may speculate as to why it is necessary to assume that both complex onsets and adjuncts are occurring at the third point in time, when it could be assumed that all consonant sequences are surfacing as complex onsets. This assumption could be argued for by appealing to the alternative constraint ranking that is shown in (19) below and illustrated in Tableau 7.

(19) Speech sample 3, alternative: ADJ-/s/, MAX ≫ *ADJ ≫ *M/SON ≫ *M/OBS ≫ IDENT ≫ *COR, *COMP

TABLEAU 7. *Speech sample 3, alternative analysis: all consonant sequences are complex onsets*

	ADJ-/s/	MAX	*ADJ	*M/SON	*M/OBS	IDENT	*COR	*COMP
'blow' /blo/								
☞ a. blo				*	*			*
b. bo		*!			*			
c. lo		*!		*				
d. b.lo	*!		*	*				
'sky' /skaɪ/								
☞ a. skaɪ					**		*	*
b. saɪ		*!			*		*	
c. kaɪ		*!			*			
d. s.kaɪ			*!		*		*	
'snow' /sno/								
☞ a. sno				*	*		*	*
b. so		*!			*		*	
c. no		*!		*				
d. s.no			*!	*			*	
'spray' /spreɪ/								
☞ a. spreɪ				*	**		*	*
b. preɪ		*!		*	*			*
c. s.peɪ		*!	*		*		*	
d. s.preɪ			*!	*	*		*	*
'sunny' /sʌni/								
☞ a. sʌni					*		*	
b. tʌni					*	*!	*	
c. gʌni					*	*!		
d. ʌni		*!						

The ranking in (19), while a possible grammar, should not be expected to occur for KR, given that we have no evidence in support of the demotion of *M/SONORANT, *M/OBSTRUENT, and IDENT below *ADJUNCT. Furthermore, it is generally agreed that promotion of constraints (that is, of *ADJUNCT over *M/SONORANT and *M/OBSTRUENT) does not occur with constraint reranking (Tesar & Smolensky, 1998).

The patterning of the /ʃ/-sequences in KR's phonology should be noted. At speech sample 1, he produces *shrub* as [wʌb], which is consistent with the behaviour of his productions for the target /s/-sequences. Indeed, the constraints and their proposed ranking can account for that production assuming [ʃ] is a violation of *COR/#_. At speech samples 2 and 3, *shrub* is produced as [ʃab] and [ʃwʌb], respectively, which suggests that /ʃr-/ patterns as other non-/s/-sequences do. Recall that the ADJUNCT-/s/ constraint family favours apical coronals over nonapical coronals. In English, the /ʃ/ is typically viewed as laminal (Keating, 1991). Therefore, the constraint family would disfavour an output form with [ʃ] as an adjunct. It has been noted, however, that the /ʃ/-sequences pattern similarly to the /s/-sequences in fully developed English (e.g. Kenstowicz, 1994). For example, in Yiddish loan words, /l/, nasals, and stops may follow /ʃ/, as in the words *schlep*, *schmuck*, and *schtick*. Aside from such borrowings, however, /ʃ/ does not combine with any other consonant in the word-initial position, with the exception of /r/. Even more curious is the absence of [sr-] sequences. The occurrence of [ʃr-] has been accounted for in derivational frameworks whereby it derives from /sr-/ by a special rule that palatalises /s/ before /r/ in the onset (Kenstowicz, 1994). This does not seem consistent with KR's data at speech sample 2. If the /ʃ/-sequences are assumed to pattern as the /s/-sequences do, then we would expect *shrub* to surface as an adjunct at that point in time. Since *shrub* is the only /ʃr-/ word targeted across the three points in time, it is difficult to make an accurate generalization regarding this consonant sequence. It is assumed that it is treated as a complex onset in KR's grammar, and this is supported by the proposed constraint ranking.

The /θr-/ sequences also warrant attention because, like /ʃ/, /θ/ is coronal and continuant. Dentals can be produced with either an apical or a laminal articulation; however, when both dentals and alveolars are contrastive in a language, they differ in terms of apicality (Keating, 1991). Yip (1991), who characterizes the apical-laminal difference in terms of the feature [distributed], notes that dentals and palatals behave as noncoronals in certain regards. Note that KR's /θr-/ sequences pattern with non-/s/-sequences across all three points in time. Singleton /θ/ was never produced correctly in any target context at speech sample 1 and was substituted with [g] initially and [s ~ ʃ] postvocalically. At speech sample 2, /θ/ was produced correctly in word initial position and as [s ~ ʃ] postvocalically. At speech sample 3, it was produced correctly in all three contexts. Despite singleton production patterns, /θr-/ was produced as [f-], [f-], and [fw-] at speech samples 1, 2, and 3, respectively. This is based on only two words with the same morpheme: *throw* and *throwing*. While it appears that labial place assimilation and/or coalescence may be occurring in this case (Ingram, 1989), limited data prevent making a reliable generalization regarding these sequences. Nevertheless, it is clear that target /θr-/ patterns differently from the /s/-sequences.

A typology of grammars

This longitudinal account has provided support for a possible typology of grammars, as in (20). The ranking in (20a) is supported by the occurrence of many languages that do not allow consonant sequences, such as Fijian (Schütz, 1980). The ranking in (20b) may be supported by those languages that allow only /s/- (and /ʃ/- or /ɬ/-) sequences, such as Acoma (Miller, 1965) discussed earlier. The ranking in (20c) allows for complex onsets. This ranking is rejected in the analysis of KR's grammar; however, it does occur, for example, in Spanish, which does not allow initial /s/-sequences (Harris, 1969). Recall that other fully developed languages that have both complex onsets and adjuncts as in ranking (20d) are Italian (Davis, 1990), Sanskrit, Gothic, and Ancient Greek (Steriade, 1988).

(20) Typology of constraint rankings

a. No consonant sequences:	*COMPLEX, *ADJUNCT ≫ MAX
b. Adjuncts only:	*COMPLEX ≫ MAX ≫ *ADJUNCT
c. Complex onsets only:	*ADJUNCT ≫ MAX ≫ *COMPLEX
d. Both complex onsets and adjuncts:	MAX ≫ *COMPLEX, *ADJUNCT

Of course, determining the specifics for each language – that is, which individual segments can occupy the adjunct position, and what kinds of consonant sequences constitute allowable complex onsets – requires an appeal to additional constraints such as the ADJUNCT-/s/ constraint family as well as the *M/SONORANT and *M/OBSTRUENT constraints. This will allow for the variation that occurs in the patterning of the /s/ + sonorant sequences across grammars. In the present case, the /s/ + sonorant sequences were analysed as adjuncts; however, they may not be analysed as such for all grammars – for example, Sanskrit (Steriade, 1988). In such a case, additional appeal to the sonority sequencing principle via minimal distance constraints may be necessary.

The typology in (20) applies not only to adult grammars, but also to both normally developing and phonologically disordered systems, as similarities have been found between the two (Ingram, 1989; Smit, 1993). Importantly, because of this noted variation in the patterning of /s/-sequences, it is therefore possible that not all children will pass through all the stages in (20).

It is of course assumed that most children learning English (for example) will pass through a stage in which no consonant sequences are produced (as in (20a)). Recall that, from the first stage of KR's documented phonological development, adjuncts were theoretically allowed to occur (if not for the high-ranking *COR/#_ and ADJUNCT-/s/ constraints), since *ADJUNCT was low-ranked. It is possible, and perhaps likely, that *ADJUNCT was ranked relatively high at an earlier stage of development, such that KR's grammar represented the ranking shown in (20a). The absence of data from an earlier point in time prevents the verification of this, however.

It is also assumed that most children will reach a stage in which all consonant sequences are produced correctly. The typology in (20) suggests it is theoretically possible that a child could approximate the target system and represent all consonant sequences as adjuncts, or all consonant sequences as complex onsets. Because we are referring to an abstract structure, the individual differences in representation will not have an impact on ordinary speech. Where we might find evidence of this differing structural representation is (in addition to children's error patterns in the present case) in speech errors and language games with both children and adults. That is, one speaker might show patterns with certain consonant sequences that another speaker might not. This has already been established in adults' and children's production patterns for consonant + /j/ sequences, where for some speakers /j/ patterns as part of a complex onset, while for others /j/ patterns as part of a diphthong (Davis & Hammond, 1995; Barlow, 1997).

This has important treatment implications as well. Treatment on /s/-sequences is a widely practiced remediation strategy for facilitating singleton /s/ production as well as elimination of the consonant sequence reduction error pattern (Hodson & Paden, 1991). From an optimality theoretic perspective, then, treatment is aimed at demoting markedness constraints such as *COMPLEX, in order to get the child's grammar more in line with the target grammar. Recall that Gierut (1999) determined that treatment on /s/ + stop sequences does not promote widespread change across all consonant sequence types, while treatment on other consonant sequences did. If we take into consideration the possibility that a child may learn /s/-sequences as structurally different from other consonant sequences, then Gierut's findings are not surprising. That is, a child who was taught /s/-sequences may have only demoted the markedness constraint *ADJUNCT, and accordingly only learned adjuncts. Consequently, treatment on non-/s/-sequences may be more appropriate for elimination of the consonant sequence reduction pattern of obstruent + sonorant sequences.

Outstanding issues

One aspect of this analysis that has not yet been addressed is specifically how KR's grammar changed over time. That is, how do constraints rerank over time? The general assumption is that markedness constraints are demoted over time, which results indirectly in the promotion of certain faithfulness constraints (e.g. Tesar & Smolensky, 1998). The present account involved demotion of two markedness constraints over time: *COR/#_ and *COMPLEX. Specifically what it is that triggers the constraint reranking continues to be debated in the literature, and the reader is referred to those references. However, Tesar & Smolensky (1998) have proposed that, initially, constraints are ranked equally. Only when there is positive evidence that two particular constraints are not equally ranked does a reranking occur. Because this view suggests that rampant variability would occur with early speech, and because children's constraint rankings do not always appear to be in the direction of more adult-like rankings, other views have been proposed (e.g. Bernhardt & Stemberger, 1998; Pulleyblank & Turkel, 1998). Pulleyblank & Turkel (1998) argue that constraints are not initially equally ranked, but rather hierarchically or semi-hierarchically ranked. Change in rankings occurs through random mutations, similar to biological evolution, where some mutations result in more optimal rankings, and others result in less optimal ones. Regardless of the learning algorithm adopted, it is generally assumed that a child's grammar will rest in its final ranking when it cannot set apart the ability of two different rankings (grammars) to generate the adult language. This allows for the possibility that the child's final ranking may not correspond exactly to the adult ranking, which in turn allows for language variation and diachronic change (Pulleyblank & Turkel, 1998). This lends further support to the possibility that English speakers may have differing structural representations for target consonant sequences due to differing constraint rankings. Finally, Boersma (1997) proposes a MINIMAL GRADUAL LEARNING ALGORITHM which allows for gradual change whereby, at certain points in time, variation may occur – a common tendency in phonological acquisition that is often difficult to account for theoretically. As stated previously (Case Study), this algorithm may be useful in accounting for the optionality of KR's pattern of velar replacement for the target alveolar stops at speech sample 1.

It was noted in the Introduction that the early emergence of /s/-sequences in some children's grammars is unexpected, given that such consonant sequences have generally been considered marked relative to other consonant sequences. Acquisition of these presumably marked /s/-sequences, particularly /s/+stop sequences, before other less-marked sequences is not predicted by developmental norms, as stated previously. Yet these sequences occurred in KR's productions before many of the presumably unmarked sequences. This developmental path has been documented in other studies as well (Smit, 1993; Gierut, 1999). Exceptions such as this would seem to force reconsideration of claims about order of acquisition as a criterion for markedness. It is argued, however, that the facts of acquisition do not necessarily contradict markedness claims. Differences in order of acquisition are due, instead, to different structural representations across speakers, which are in turn due to different constraint rankings. This difference may be further reflected in noted variable patterns of substitution and reduction (Smit, 1993).

Fikkert (1994) has addressed the markedness relationship between adjuncts and complex onsets in the acquisition of Dutch by appealing to a parametric approach where the possibility of having extrasyllabic consonants (that is, /s/ as an adjunct) must be defined by a parameter, just as the possibility of having complex onsets must be defined by a parameter. Fikkert assumes these parameters are independent: consequently, some children first set the extrasyllabic parameter to the marked value, while others first set the complex onset parameter to the marked value. The fact that there are fully-developed languages which can allow for one type of consonant sequence to the exclusion of the other type suggests that the two types of consonant sequences are not marked relative to one another cross-linguistically; rather, markedness relationships between these two structural representations can only be considered within an individual grammar. This is consistent with Fikkert's (1994) analysis as well as the present one. One difference between her account and the present one is that she crucially assumes that only the /s/+stop sequences have this special status with /s/ as extrasyllabic. She claims that the /s/+sonorant sequences are not expected to pattern in the same way as /s/+stop sequences in development, and this is supported by her data on the acquisition of Dutch. This is not supported by evidence from KR's acquisition of English.

Within the framework of optimality theory, constraints, rather than parameters, are appealed to: in some grammars, *ADJUNCT is ranked lower than *COMPLEX (as in the case of KR), making adjuncts unmarked relative to complex onsets, while in other grammars the opposite ranking occurs, making adjuncts marked relative to complex onsets. Previous accounts of markedness and consonant sequences have referred to comparisons of consonant sequences versus singletons, segmental and sonority differences. However, given the proposed structural differences for consonant sequences, markedness relationships should also consider structural representation, which optimality theory allows. Based on this and previous evidence, it is apparent that adjuncts and complex onsets are not in a markedness relationship with one another.

Now that we have considered such issues within the framework of optimality theory, we may also look at the discrepancy between typological criteria and order of acquisition criteria from a different perspective. It has been argued that markedness constraints generally outrank faithfulness constraints in the early stages of developing systems in order to account for the fact that children's productions are reduced and simplified. This suggests, then, that markedness is not necessarily determined by facts about order of acquisition; rather, the unmarkedness that is found in order of acquisition evidence is simply an ENTAILMENT of high-ranking constraints that express properties of markedness (Jakobson, 1968; Smolensky, 1996). Such an assumption is particularly compelling if we consider that the use of multiple criteria in classical markedness definitions has been problematic. Deviations from predicted order of acquisition now may be explained by differences in the relative rankings of markedness constraints, and such inconsistencies are no longer problematic.

REFERENCES

Barlow, J. A. (1997). A constraint-based account of syllable onsets: evidence from developing systems. Unpublished doctoral dissertation, Indiana University.

Barlow, J. A. & Dinnsen, D. A. (1998). Asymmetrical cluster development in a disordered system. *Language Acquisition* **7**, 1–49.

Bernhardt, B. & Stemberger, J. P. (1998). *Handbook of phonological development: from the perspective of constraint-based nonlinear phonology*. San Diego, CA: Academic Press.

Bernhardt, B. & Stoel-Gammon, C. (1996). Underspecification and markedness in normal and disordered phonological development. In C. E. Johnson & J. H. V. Gilbert (eds), *Children's language*. Mahwah, NJ: Erlbaum.

Blevins, J. (1995). The syllable in phonological theory. In J. A. Goldsmith (ed.), *The handbook of phonological theory*. Cambridge, MA: Blackwell.

Boersma, P. (1997). Sound change in functional phonology. Unpublished manuscript, University of Amsterdam, The Netherlands.

Clements, G. N. (1990). The role of the sonority cycle in core syllabification. In J. Kingston & M. E. Beckman (eds), *Papers in laboratory phonology I: between the grammar and physics of speech*. New York: Cambridge University Press.

Davis, S. (1990). Italian onset structure and the distribution of *il* and *lo*. *Linguistics* **28**, 43–55.

Davis, S. & Hammond, M. (1995). On the status of on-glides in American English. *Phonology* **12**, 159–82.

Elbert, M., Dinnsen, D. A. & Powell, T. W. (1984). On the prediction of phonologic generalization learning patterns. *Journal of Speech and Hearing Disorders* **49**, 309–17.

Elbert, M., Dinnsen, D. A., Swartzlander, P. & Chin, S. B. (1990). Generalization to conversational speech. *Journal of Speech and Hearing Disorders* **55**, 694–9.

Fikkert, P. (1994). *On the acquisition of prosodic structure*. Doctoral dissertation, Leiden University, The Netherlands.

Gierut, J. A. (1985). On the relationship between phonological knowledge and generalization learning in misarticulating children. Doctoral dissertation, Indiana University. [Published by Indiana University Linguistics Club, Bloomington, IN, 1986.].

Gierut, J. A. (1999). Syllable onsets: clusters and adjuncts in acquisition. *Journal of Speech, Language, and Hearing Research* **42**, 708–26.

Gnanadesikan, A. E. (1996). Child phonology in optimality theory: ranking markedness and faithfulness constraints. In A. Stringfellow, D. Cahana-Amitay, E. Hughes & A. Zukowski (eds), *Proceedings of the 20th Annual Boston University Conference on Language Development*. Somerville, MA: Cascadilla Press.

Goldman, R. & Fristoe, M. (1986). *Goldman-Fristoe Test of Articulation*. Circles Pines, MN: American Guidance Service.

Harris, J. (1969). *Spanish phonology*. Cambridge, MA: MIT Press.

Hodson, B. W. & Paden, E. P. (1991). *Targeting intelligible speech: a phonological approach to remediation*. Austin, TX: Pro-Ed.

Ingram, D. (1989). *Phonological disability in children*. London: Cole & Whurr.

Jakobson, R. (1968). *Child language*, *aphasia and phonological universals*. The Hague, Netherlands: Mouton.

Keating, P. A. (1991). Coronal places of articulation. In C. Paradis & J.-F. Prunet (eds), *Phonetics and phonology, Vol. 2 : the special status of coronals : internal and external evidence*. San Diego: Academic Press.

Kenstowicz, M. (1994). *Phonology in generative grammar*. Cambridge, MA: Blackwell.

Kim, S. (1990). A nonlinear analysis of reduplicating preterites in Germanic. *Linguistic Analysis* **20**, 104–18.

McCarthy, J. J. & Prince, A. S. (1995). Faithfulness and reduplicative identity. In J. N. Beckman, L. W. Dickey & S. Urbanczyk (eds), *Papers in optimality theory* (*University of Massachusetts Occasional Papers 18*). Amherst, MA: GLSA, University of Massachusetts.

Miller, W. R. (1965). *Acoma grammar and texts*. Berkeley, CA: University of California Press.

Paradis, C. & Prunet, J. F. (eds). (1991). *Phonetics and phonology, Vol. 2 : the special status of coronals : internal and external evidence*. San Diego, CA: Academic Press.

Prince, A. & Smolensky, P. (1993). *Optimality theory : constraint interaction in generative grammar : technical report no. 2*. New Brunswick, NJ: Rutgers Center for Cognitive Science, Rutgers University.

Pulleyblank, D. & Turkel, W. J. (1998). The logical problem of language acquisition in optimality theory. In P. Barbosa, D. Fox, P. Hagstrom, M. McGinnis & D. Pesetsky (eds), *Is the best good enough? Optimality and competition in syntax*. Cambridge, MA: MIT Press.

Schütz, A. J. (1980). *The Fijian language*. Honolulu, HI: University of Hawaii Press.

Selkirk, E. O. (1982). The syllable. In H. van der Hulst & N. Smith (eds), *The structure of phonological representations*. Dordrecht, Netherlands: Foris.

Sherer, T. (1994). Prosodic phonotactics. Unpublished doctoral dissertation: University of Massachusetts, Amherst.

Smit, A. B. (1993). Phonologic error distributions in the Iowa-Nebraska Articulation Norms Project: Word-initial consonant clusters. *Journal of Speech and Hearing Research* **36**, 931–47.

Smit, A. B., Hand, L., Freilinger, J. J., Bernthal, J. E. & Bird, A. (1990). The Iowa Articulation Norms Project and its Nebraska replication. *Journal of Speech and Hearing Disorders* **55**, 779–98.

Smolensky, P. (1996). *The initial state and 'richness of the base' in optimality theory : technical Report JHU-CogSci-96–4*. Baltimore, MD: Department of Cognitive Science, Johns Hopkins University.

Stemberger, J. P. & Treiman, R. (1986). The internal structure of word-initial consonant clusters. *Journal of Memory and Language* **25**, 163–80.

Steriade, D. (1988). Reduplication and syllable transfer in Sanskrit and elsewhere. *Phonology* **5**, 73–155.

Steriade, D. (1994). Complex onsets as single segments: the Mazateco pattern. In J. Cole & C. Kisseberth (eds), *Perspectives in phonology*. Stanford, CA: Center for the Study of Language and Information.

Tesar, B. & Smolensky, P. (1998). Learnability in optimality theory. *Linguistic Inquiry* **29**, 229–68.

Treiman, R., Gross, J. & Cwikiel-Glavin, A. (1992). The syllabification of /s/ clusters in English. *Journal of Phonetics* **20**, 383–402.

Yip, M. (1991). Coronals, consonant clusters and the coda condition. In C. Paradis & J.-F. Prunet (eds), *Phonetics and phonology, Vol. 2 : the special status of coronals : internal and external evidence*. San Diego: Academic Press.