

The Development of sC Onset Clusters in Interlanguage: Markedness vs. Frequency Effects

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1 Introduction

The concept of markedness, as it is recognized today, has its origin in phonology, most notably in the work of Trubetzkoy (1939). After the advent of generative linguistic theory in the 1960s and its subsequent expansion into areas such as second language acquisition (e.g. White 1982), the concept was incorporated into the field with convincing predictive and explanatory powers in the form of Eckman's (1977:321) Markedness Differential Hypothesis (MDH): "The areas of difficulty that a language learner will have can be predicted on the basis of a systematic comparison of the grammars of the native language, the target language and the markedness relations stated in universal grammar". Since then, the notion of markedness has been extensively used as a tool to explain L2 acquisition phenomena (e.g. Carlisle 1988 et seq., Major 1996, Abrahamsson 1999, Rebello and Baptista 2006, Escartin 2005, Yavaş 2006, Yavaş and Barlow 2006, Cardoso 2007). More recently, there has been a major shift in linguistics with the emergence of usage-based approaches that support the notion that linguistic representation (i.e. competence, in generative terms) is mediated by the frequency with which certain linguistic structures occur in the language (e.g. Gass 1997, Bybee 2001, Demuth 2001, Munson 2001, the volumes edited by Bybee and Hopper 2001, Bybee 2007, Trofimovich, Gatbonton and Segalowitz 2007). As expected, proponents of each of these divergent views on language have been involved in heated debates that get to the heart of the nativist (e.g. generativist) / non-nativist (e.g. constructivist) dichotomy. The objective of this investigation is to assess these two diverging approaches based on how they manage to account for the developmental path that L2 learners follow in the acquisition of foreign /s/-initial onset clusters.

Specifically, this study investigates the effects of markedness and input frequency in the variable acquisition of /s/ plus consonant (sC henceforth) onset clusters in the speech of Brazilian Portuguese (BP) speakers learning English as a second/foreign language (ESL) in a classroom environment. The study focuses on the development of the homorganic /st/, /sn/, and /sl/ sequences, which syllabify

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variably either via prothesis, a typical BP transfer phenomenon that inserts an [i] before these illicit clusters (e.g. [i]stop, [i]slide), or via its target L2 pronunciation (e.g. [s]top, [sl]ide). The selection of these homorganic clusters was strategic because they constitute a set in which place of articulation is maintained constant (the three clusters all share the coronal articulator), which allows us to categorize them on the single dimension that distinguishes them: sonority. Moreover, heterorganic clusters (e.g. /sm/, /sk/) are more marked in comparison with those that share their articulators (based on Clements' 1990 Sequential Markedness Principle; see forthcoming discussion in section 3).

Unlike most frequency-based studies in which there is an overlap between what is predicted by markedness and frequency (e.g. Hale 1945, Leonard and Ritterman 1971, Levelt, Schiller and Levelt 2000, Zamuner 2003, Trofimovich et al. 2007), these clusters are of particular relevance to test the effects of markedness against input frequency because they make different predictions regarding their order of acquisition. For instance, if L2 learners are sensitive to markedness, they should acquire the least marked /sl/ sequence before the more marked /sn/ and /st/, as predicted by Clements' (1990) Sonority Cycle and its corollary principles Sonority Sequencing and Minimal Sonority Distance (see section 3). However, if L2 learners are sensitive to the frequency of these clusters in the input, they should acquire the most frequent form /st/ before /sl/ and /sn/ (see section 4). The frequency data are drawn from an oral corpus specially designed for this study, which consists of the student-directed speech (teacher talk) of an English teacher over a two-month period. A summary of the predictions is illustrated below (where ">" indicates "acquired before" or "more easily articulated than").

(1) Developmental order of sC clusters: Two hypothetical learning paths

- | | | | | | |
|-----------------------|----|---|----|---|----|
| a. Markedness effect: | sl | > | sn | > | st |
| b. Frequency effect: | st | > | sl | > | sn |

To investigate the effect of markedness and frequency on the acquisition of sC clusters, 10 native BP speakers from two levels of proficiency in English (i.e. low intermediate and advanced) were interviewed. The interviews followed standard sociolinguistic procedures for data collection and included a set of linguistic and extralinguistic factors whose effects were evaluated statistically via GoldVarb X (Sankoff, Tagliamonte and Smith 2005). In general, the results indicate that learners are more likely to produce target-like sC sequences in higher proficiency levels and, more importantly, when the clusters are of the /sl/ or /sn/ type. In contrast, /st/ clusters had no significant effect on the production of sC forms, indicating that the sequence is only acquired at a later stage in the acquisition of sC structure. These results conform to the predictions of Clements' (1990) Sonority Cycle and to some of the previous studies on the subject (e.g. Carlisle 1991ab, Major 1986, Escartin 2005), and support the hypothesis that it is markedness on sonority sequencing, not input frequency, that determines the order of acquisition of sC clusters in second language speech.

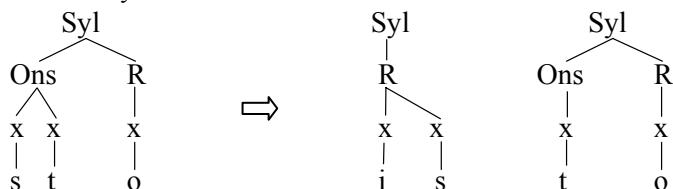
The paper is organized as follows: Section 2 provides an introduction to onset clusters in Brazilian Portuguese and in BP-based interlanguage (BPE), and describes the relevant initial and subsequent states in the phonology of these learners. The third section discusses the concept of markedness on sonority sequencing and sonority distance and, based on this discussion, proposes a hypothesis for the developmental order of sC sequences. Section 4 is devoted to the input frequency analysis of sC clusters. In the same section, a similar hypothesis for the developmental order of sC sequences is proposed, based on the phonotactic distribution of these forms in the input. The fourth section addresses the production study, whose results allow us to assess the two hypotheses for the development of sC clusters. Finally, section 5 provides a summary of the study and our general concluding remarks.

2 sC Sequences in BP and BP-based English

Word-initial complex onsets in Brazilian Portuguese are restricted to obstruent plus liquid combinations (Ferreira Neto 2001, Ribas 2004): /pr/, /br/, /tr/, /dr/, /kr/, /gr/, /fr/, /vr/, /pl/, /bl/, /tl/, /kl/, /gl/, and /fl/. As is the case with closely related Spanish (e.g. Carlisle 1988 et seq., Escartin 2005), BP disallows sC sequences to syllabify as such in word-initial and word-internal positions. In the case of the latter, the sC cluster syllabifies heterosyllabically following a set of general principles on syllabification (e.g. de/s + t/oante → de/s.t/oante 'discordant'). In contrast, when the sC cluster appears

word-initially, the same sequence can only surface if preceded by an epenthetic [i] (vocalic prothesis), in which case the sC cluster syllabifies into two separate syllables, as the derivation in (2) illustrates.

(2) sC in BP: Syllabification via Prothesis



Prothesis is a highly productive process in BP phonology: It is observed in sC-initial words originally derived from Latin, as well as in words that have been more recently brought into the language in the form of borrowings, as exemplified in (3) and (4) respectively.

(3) sC clusters in BP: A diachronic view

<u>Latin</u>		<u>Portuguese</u>	
/st/abiliscere	→	[ist]abelecer	‘to establish’
/st/ellare	→	[ist]elar	‘related to stars’

(4) sC clusters in BP: A synchronic view (via borrowings)

<u>English</u>		<u>Portuguese</u>
/sl/ide	→	[isl]ide
/sn/ob	→	[isn]nobe
/st/and	→	[ist]ande

Assuming that second language acquisition is at least in some aspects filtered through the learner’s first language (e.g. Wardhaugh 1970, Broselow 1987), a reasonable prediction is that in initial stages of L2 acquisition the learner will merely transfer her L1 knowledge onto the target language, and the mere transfer of BP phonology will take place in the form of categorical prothesis. As exposure to the L2 increases, the innovative features are gradually incorporated into the developing system and, consequently, target-like forms arise. The road to the target language, however, is paved with a high level of variability. Moreover, each of the three sC clusters under consideration develops at its own pace: While some appear early in the acquisition process, others are only fully acquired in later stages of development. The following sections will introduce the rationale behind two hypotheses for the development of sC clusters, and will address the following general questions: What linguistic and extralinguistic factors affect the development of sC sequences? In what developmental order are these clusters acquired? Consequently, which of the two hypotheses illustrated in (1) best accounts for the acquisition order in which sC are acquired in the interlanguage of BP-based English?

3 Markedness Effects on sC Clusters

Sonority is an important concept for the analysis of sC clusters as it is considered a determining factor in syllabification (e.g. Sievers 1881, Pike 1943, Selkirk 1984, Hogg and McCully 1987, Clements 1990, Dogil and Luschützky 1990, Zec 1995), and in explaining the acquisition of syllable structure in first (e.g. Ohala 1999, Yavaş 2006, Yavaş and Barlow 2006) and second language acquisition (e.g. Major 1986, 1996, 2001, Carlisle 1988 et seq. Baptista and Silva Filho 2006, Koerich 2006). The standard definition of the syllable, for instance, must refer to the concept of sonority: A syllable is comprised of an obligatory head, which constitutes the peak of sonority (usually a vowel), surrounded by segments of decreasing sonority. This sequencing of sonority within the syllable has been formalized as the Sonority Sequencing Principle (SSP; Selkirk 1984:116):

(5) The Sonority Sequencing Principle:

“In any syllable, there is a segment constituting the syllable peak [usually a vowel] that is preceded and/or followed by a sequence of segments with progressively decreasing sonority values”.

Despite its wide use as a tool to explain phenomena that revolve around the syllable, the concept of sonority is notoriously difficult to define, as it can be characterized from a variety of (sometimes overlapping) perspectives that include amplitude (acoustically defined as ‘intensity’ and perceptually as ‘loudness’ – Kent and Read 1992; e.g. Ladefoged 1993, Selkirk 1984, Clements 1990), openness of the vocal tract (e.g. Donegan 1985), propensity for voicing (Kenstowicz 1994), acoustic energy (e.g. Goldsmith 1989), etc. For a comprehensive discussion of these and more features, see Parker (2002) and Yavaş (2006). With the use of a speech analyzer such as Praat (Boersma and Weenink 2007), sonority can be visualized via the representation of the amplitude (loudness, intensity) of segments, depicted in a waveform as a bundle of vertical lines: the higher the amplitude, the higher the sonority level. Figure 1 illustrates the waveform for “Sam”, an SSP-abiding syllable that displays the low sonority of [s] and [m] with respect to the vowel [æ], and the relative difference in sonority between the less sonorous [s] and the more sonorous [m].

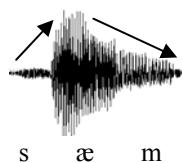


Figure 1: Waveform for “Sam” depicting sonority in terms of amplitude (loudness)

The sonority hierarchy adopted in this study is illustrated in (6), where classes of segments are organized from the least to the most sonorous for expository reasons (“<” indicates “less sonorous than” and the segments underneath these classes highlight the four segments that comprise the set of sC clusters covered by this investigation). For alternative or more detailed sonority hierarchies, see Hogg and McCully (1987) and Parker (2002).

(6) Sonority Hierarchy (adapted from Clements 1990)

Stops < Fricatives < Nasals < Liquids < Glides < Vowels
 /t/ /s/ /n/ /l/

The generalizations regarding the syllable, the SSP and the sonority hierarchy discussed thus far account for syllable structures comprised of a nucleus followed or preceded by a single consonant. They say nothing about sequencing within clusters. In the following two sections, the syllabification of pre-vocalic sC clusters will be discussed. Let us start with the syllabification of /st/.

3.1 The problem with /st/: /st/ and the Sonority Sequencing Principle

The special representational nature of sC sequences and, more specifically, of those that violate the Sonority Sequencing Principle (i.e. /s/ + stop sequences) has been the topic of heated debate in phonology over the last three decades (e.g. Fudge 1969, Vennemann 1982, Selkirk 1982, Kaye 1992, Goad and Rose 2004, Boyd 2006). One of the arguments that nourish the debate is the fact that, within the set of sC clusters, there is an asymmetry in the sonority profile of its members. For instance, employing the same visual representation for sonority using waveforms and the hierarchy discussed in (6), observe in Figure 2 that while the /sl/ sequence in [slat] ‘slot’ strictly abides by the SSP (a similar analysis holds for /sn/), the representation for /st/ in [stap] ‘stop’ violates the principle given that the sonority sequencing within the cluster decreases and then increases towards the peak of the syllable.

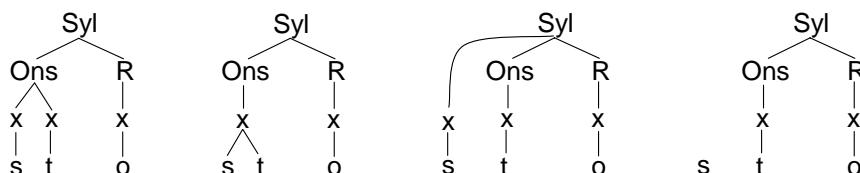


Figure 2: The SSP and its violation in terms of amplitude

Another argument that has fueled the debate relates to the asymmetries observed across sC and non-sC clusters (i.e. stop plus liquid sequences such as [pr], [kl], [br]). While the latter are typically and uncontroversially syllabified as onsets (similar to what is illustrated in (7a); e.g. Goad and Rose 2004, Boyd 2006), sC sequences are assumed to have a special status in the grammar because of their idiosyncratic behavior with respect to a variety of phonological phenomena (see Goad and Rose 2004 for an examination of some of these phenomena from an L1 acquisition perspective). Aside from the standard branching onset analysis in (7a) (e.g. Carlisle 1988 et seq., Major 1996, 2001, Ohala 1999), the other representations in (7) illustrate some of the unorthodox analyses that have been proposed to account for the peculiar behavior of /s/ in sC clusters: (1) /s/ as the first member of a complex segment (see (7b); e.g. Selkirk 1982, Lamontagne 1993, Van de Weijer 1996); (2) /s/ as Adjunct (see (7c); e.g. Barlow 2001, Barlow and Dinnsen 1998 (for /st/ and /sn/ only), Kaye 1989, Kenstowicz 1994); and (3) /s/ as Extrasyllabic (or Appendix) (see (7d); e.g. Goad and Rose 2004, Fikkert 1994, Giegerich 1992, Levin 1985). What is crucial in the alternative representations for onset clusters in (7b) through (7d) is that they eliminate potential SSP violations via the assignment of abstract representations. In this study, along the lines of Boyd (2006), we assume the standard view for the representation of sC clusters in (7a), one that assumes no structural distinction between sC and non-sC consonant sequences. For a review and critique of these alternative approaches, see Boyd (2006).

(7) The syllabification of onset clusters: Four analyses

a. Branching Onset b. Complex Segment c. Adjunct d. Extrasyllabic (Appendix)



In sum, we have established in this section a markedness relationship among sC clusters in which /st/ is more marked than /sn/ and /sl/ because the former violates the SSP. This relationship leads us to hypothesize that this more marked sC structure will be acquired at later stages in the development of English L2 syllable structure: /sl/, /sn/ > /st/.

3.2 /sn/, /sl/ and the Minimal Sonority Distance

In this section, the hierarchy based on sonority markedness among sC clusters will be further expanded to include another markedness relationship between the two sequences that adhere equally to the SSP: /sn/ and /sl/. To explain the relationship between these two clusters with respect to markedness, let us appeal to the concept of the Minimal Sonority Distance (MSD) (Clements 1990; see also Selkirk 1984, Baertsch 1998, and Carlisle 2006), formalized in (8) below. Simply put, the MSD embodies certain requirements on sonority distance imposed on syllable structure, demanding a maximal rise in sonority between two or more members of the syllable.

(8) The Minimal Sonority Distance (within complex onsets)

The second segment in an onset cluster prefers a more sonorous segment, “one with the maximal and most evenly-distributed rise in sonority” (adapted from Clements 1990:303)

Considering the two SSP-abiding sC clusters and assuming the sonority hierarchy discussed in section 3.1, observe that the sonority distance between /s/ and /l/ (distance = 2) is greater than that between /s/ and /n/ (distance = 1). From a MSD perspective, we may then assume that /sl/ is less marked than /sn/ because in the former the rise in sonority is maximal, as illustrated in the hierarchy in (9).

(9) Markedness hierarchy for SSP-abiding sC sequences: sl > sn

In general, the MSD captures the observation that onsets are maximally low in sonority (e.g. Jakobson's 1941 Principle of Maximal Contrast, which results in the following markedness hierarchy with regards to onsets, going from the least to the most marked structure: stops < fricatives < nasals < liquids < glides). The arguments in favor of the MSD as a tool to establish markedness relationships in sC clusters are based on at least two factors. Firstly, the MSD reflects in a subtle way the universal tendency for syllables to follow the canonical CV structure. Having a higher level of sonority, the second element in the sC cluster will resemble the more sonorous peak, resulting in a high sonority distance between /s/ and the following consonant plus vowel sequence. Secondly, there is considerable evidence from L1 acquisition that supports the preference for less sonorous onsets. In the presence of sC clusters, for instance, the most common strategy to syllabify this complex structure is to simply delete the more sonorous segment (underlined in the examples that follow) and preserve the element with the least amount of sonority (Sonority-based selection; e.g. Chin 1996, Gnanadesikan 2004, Goad and Rose 2004, Ohala 1996, 1999, Pater and Barlow 2003): /st/ op → [t] op, /sl/ eep → [s] eep.

The markedness relationships between the sC clusters under investigation have now been established based on the principles of sonority sequencing and the minimal sonority distance between onset members. This results in a hierarchy in which /sl/ is less marked than /sn/, which are both in turn less marked than the SSP-violating /st/ cluster.

3.3 sC Sequences in Second Language Acquisition: Previous Studies

In the previous section, it was shown that one of the strategies commonly used by L1 learners to syllabify complex sC onsets is the deletion of the most sonorous segment. In second language acquisition, on the other hand, the most common strategy to syllabify illicit sC sequences is vocalic epenthesis (Broselow 1984, Samarajiwa and Abeysekera 1964, Swift 1963, Yarmohammadi 1969). This section aims to provide a succinct overview of some of the relevant studies on the L2 acquisition of sC clusters involving Brazilian Portuguese and one of its closely-related siblings, Spanish. For ease of exposition and due to space limitations, the studies are compiled in a diagrammatic fashion where we illustrate their authors, the number of participants in each study, the L1 and L2 involved, the order of acquisition of the sC sequences (simplified; only relevant clusters are shown), and a rating scheme that illustrates whether the results obtained in that particular study corroborate or challenge the predictions based on markedness involving sonority, as discussed in the preceding section.

Table 1: sC clusters in L2 acquisition

Study	Participants	L1	L2	sC order of acquisition	Rating ^c
a. Carlisle (1988)	14 adults	Sp ^a	Eng	sl > sn, sm	***
b. Carlisle (1991b)	11 adults	Sp	Eng	sl > st	***
c. Carlisle (2006)	17 adults	Sp	Eng	sl > sn > st	***
c. Tropf (1987)	11 adults	Sp	Ger	ʃl, ʃr, ʃn, ʃm > ʃv, ʃp, ʃt	***
d. Escartin (2005)	23 adults	Sp	Eng	sm, sn > sl, sp, sk, st	**
e. Abrahamsson (1999)	1 adults	Sp	Swd	sn, sm > st, sp, sk > sl	**
f. Major (1996)	4 adults	BP	Eng	sp, sk, st > sl (other clusters)	
g. Rebello (1997)	6 adults	BP	Eng	sp, sk, st, sl > sm, sn	*
h. Rauber (2006)	10/9 adults	BP ^b /Sp	Eng	sm, sn, sl, sw > sp, st, sk	***

^a Sp= Spanish, BP = Brazilian Portuguese, Eng = English, Ger = German, Swd = Swedish;

^b In BP, there was no significant difference across the sets of clusters

^c Rating scale: *** (as predicted by the SSP) to no asterisks (contradictory results)

Leaving aside the intricacies particular to each analysis and focusing on what is displayed in Table 1, two general patterns can be delineated: One in which the development of sC structure follows the path predicted by sonority (represented by the majority of the studies involving Spanish in (a) through (e), and one in which the results remain inconclusive with respect to sC development (represented by Brazilian Portuguese in (f) through (h)). What cannot be deduced from Table 1 are some of the factors or issues that were not considered or controlled for in the studies. Here are some of the oversights that are being addressed in the present investigation: (1) With the exception of some of Carlisle's investigations, these studies ignore the effect that heterorganicity may have on the production of sC sequences. For instance, while /sn/ and /sm/ are equally marked with respect to sonority sequencing, they differ in place of articulation. Considering Clements' (1990:313) Sequential Markedness Principle ("For any two segments A and B and any given context X_Y, if A is simpler than B, then XAY is simpler than XBY") and the fact that the coronal /n/ is less marked than the labial /m/, it follows that the /sn/ sequence is the least marked of the two clusters. Obviously, the homorganic sC clusters violate a phonotactic constraint against homorganicity (the Obligatory Contour Principle for Place – OCP-Place: Adjacent identical place features are prohibited; McCarthy 1988; see also Carlisle 2006), which is strongly operative in English as the following unattested sequences show: *dl, *tl, *pw, *fw. (2) None of these studies examined the role of input frequency in determining the path of development of sC clusters. Consider the results of Major (1996), for instance. Assuming that the incidence of /s/ + stops sequences in English is considerably higher than that of /s/ + liquid clusters (see section 4 for the actual distribution), it is plausible to hypothesize that the former will be acquired first in the acquisition of the target language (this hypothesis, however, will be refuted in section 5). Accordingly, (3) none of these studies attempted to examine and assess the explanatory power of both input frequency and markedness as analytical tools to explain the development of sC clusters in interlanguage.

3.4 Conclusions

In this section, we have shown that an all-encompassing explanation for the development of sC clusters in interlanguage is far from conclusive, especially in the context of Brazilian ESL learners.

With regards to sonority and its effect on sC sequences, we have established that: (1) /st/ is the most marked of the set of sC clusters under consideration: It not only violates sonority sequencing, but the sonority distance between its two members is not maximal (it is in fact a sonority reversal); and (2) the /sn/ cluster is more marked than /sl/ because the sonority distance between the two members of the former is smaller than that of /s/ and /l/. Assuming that unmarked structures are acquired before more marked ones, the following learning path for the development of sC clusters is predicted:

(10) Developmental order of sC clusters – Markedness effects: sl > sn > st

4 Frequency Effects on sC Sequences

An alternative way of examining developmental outcomes is via an approach that recognizes that language users are highly sensitive to the frequency with which certain linguistic structures occur in the language (e.g. Leonard and Ritterman 1971, Gass 1997, Bybee 2001, Demuth 2001, Munson 2001, the volumes edited by Bybee and Hopper 2001, Bybee 2007, Trofimovich et al. 2007). In this approach, it is assumed that linguistic knowledge (competence) is mediated by frequency (quantified in *probabilistic* rather than absolute terms, as is customary in standard generative linguistic theory): Learners build linguistic representations according to the frequency of structures or patterns in the input. However, there is also ample evidence that frequency has little or no effect in accounting for certain linguistic phenomena (e.g. Moore, Burke and Adams 1976, Bennet and Ingle 1984, Spada and Lightbown 1993, Lightbown and Spada 1999, White 1991, Labov 2003, Davidson, Jusczyk and Smolensky 2004, Kirk and Demuth 2005, Davidson 2006). In addition, some studies emphasize an equal role for both frequency and markedness in determining the course of language acquisition, depending mostly on individual differences (e.g. Levelt, Schiller and Levelt 2000, Stites, Demuth and Kirk 2004).

We will now explore the concept of input frequency as a tool to account for the developmental stages that characterize the acquisition of sC sequences in BPE.

4.1 The L2 corpus

The L2 corpus collected for the frequency study consists of approximately 30 hours of audio recordings of one highly proficient ESL teacher’s input to adult learners in two standard language classrooms (beginning and intermediate levels), over a period of two and a half months. The audio recordings were conducted at a private language school in the city of Belém, Brazil. The collected corpus of teacher’s speech was transcribed by two research assistants using Transcriber (version 1.5.1), which yielded 837 instances of sC sequences. Because a preceding vocalic environment (V) is more likely to trigger the resyllabification of the cluster into two separate syllables (e.g. /st/ → [Vs.t]op; see Carlisle 1988 et seq. for Spanish, and Rauber 2006, Rebello 1997, and Rebello and Baptista 2006 for BP), only instances in which the cluster was preceded by a pause or a consonant were counted for the frequency analysis. For the recording, a Zoom H4 Flash Recorder (with a built-in pair of microphones in an X/Y configuration) was utilized. The recorder was placed on the teacher’s desk so that it could capture with greater precision the closest sound source, the speech produced by the teacher.

4.2 Results and Discussion

The results of the corpus-based analysis are presented in (11), where we show the frequency with which each cluster appears in the input, the student-direct speech produced by the English teacher. Observe that the frequency of /st/ in the corpus is considerably higher (87.4%) than for the /sl/ and /sn/ clusters (6.4% and 6.2% respectively).

(11) Distribution (N and %) of sC clusters in student-directed speech

sC Sequences – Total: 837	
<i>st</i>	731 (87.4%)
<i>sl</i>	54 (6.4%)
<i>sn</i>	52 (6.2%)

Note in Table (2) that the probabilistic distribution of sC in the input is not an idiosyncrasy of BP-based interlanguage, since data from different corpora including written (a-b) and oral (c) language as well as French-based interlanguage (c) demonstrate the same pattern in which /st/ is considerably more frequent than its SSP-abiding pairs.

Table 2: The distribution of sC clusters across different corpora

Corpora	Total (N)	sC-initial words (%)		
		<i>st</i>	<i>sl</i>	<i>sn</i>
a. L2 textbook: Written	140	90.7	5.7	3.8
b. Brown Corpus: Written (Kucera and Francis 1967)	10,900	87.9	9.3	2.7
c. ALERT Corpus: L2 oral (Collins et al. 2006)	1,020	90.7	5.7	3.8

From the distribution of sC sequences in (11) and Table 2, we may conclude two important points: Firstly, the results clearly show that frequencies from different corpora correlate fairly highly when broad-grained categories of frequency are used (see also Jurafsky 2003 for a similar view). Secondly, assuming that “the productivity of a pattern [...] is largely determined by its type frequency: the more items encompassed by a schema, the stronger it is, and the more available it is for application to new items” (Bybee 2001:13), the following learning path for sC clusters is predicted, in which the considerably more frequent /st/ is predicted to develop before (or be more easily articulated than) its less frequent counterparts /sl/ and /sn/:

(12) Developmental order of sC clusters – Frequency effects: *st* > *sl* > *sn*

5 The Acquisition of sC in Interlanguage: A Variationist Analysis

To contrast the two hypotheses regarding the developmental path of sC sequences in BPE, a production study was designed, involving the same students whose teacher was audio recorded for the frequency study described in the previous section. The production study adopts a sociolinguistic (variationist) methodology for data collection in order to obtain a reliable corpus of variable data such as those encountered in developing languages. As is customary in variationist studies, the study also includes separate tasks to elicit distinct levels of formality. It is cross-sectional and involves the participation of 10 English learners, stratified into two proficiency groups. Following the standard sociolinguistic view that “the individual doesn’t exist as a unit” because language is the property of the community (Labov’s answer to an interview question in Gordon, 2006, p. 341), we assume in this study that proficiencies constitute different speech communities and, consequently, that the patterns of inherent variable behavior within the individual (i.e., the participant) are similar to those encountered within the group (i.e., proficiency). For data and analyses that confirm this claim in a second language environment, see Bayley 1991, Regan 1996, 2004, and Young 1991.

5.1 Data Collection Procedures

The methodology for data elicitation was to some extent inspired by Labov’s (1966) seminal investigation of the pronunciation of (r) in coda position in three New York City department stores. Briefly, Labov attempted to elicit the phrase “fourth floor” from sales representatives by asking for the location of items found on the *fourth floor*. Whenever a response was provided (casual speech), Labov would search for a more careful repetition of “fourth floor” by pretending not to hear the salesperson’s response (careful speech). The current study followed a similar procedure for data elicitation, except that the target phrase “fourth floor” was replaced by sC-initial words, elicited via a picture naming task consisting of 12 pictures representing words that start with the relevant clusters (e.g. [sn]ake, [st]op, [sl]eep – pictures not subject to copyright, downloaded from Yotophoto: <http://yotophoto.com>). In this task (to which we will occasionally refer as picture naming), participants were sporadically asked questions such as “What’s this?”, “What do you see?”. They were also asked to pronounce only the word shown (i.e. without articles or vowel-final words, in which case the sC onset would syllabify in two separate syllables). Mimicking Labov’s tactic, the interviewer pretended not to hear the participant’s response by using body language or asking questions such as “Can you say that again?” For convenience and in the spirit of the variationist methodology adopted, the first and more spontaneous utterance was interpreted as *less formal (first reply)* while the second, more careful response (in which more attention is paid to speech) was coded as *formal (careful reply)* (see Labov 1972, Eckert and Rickford 2001, Diaz-Campos 2006, Escartin 2005, John 2006 for similar approaches to defining style). Finally, another more standard type of interview was used to collect more spontaneous speech: *Informal (interview with pictures)*. In this task, the participants were engaged in conversation based on the pictures provided. For instance, when shown the picture of a snake, they were asked questions such as “Do you like these animals?”, “Have you even seen one?”, “Do you know someone who has eaten one?”.

(13) Pictures used in the interviews: A sample



The use of pictures in the interview was found to be a convenient way of obtaining a significant number of relevant tokens across different styles: Not only is learner speech characterized by monostylism in earlier stages of acquisition (Cardoso 2007), but the incidence of /s/ plus stop coronals is considerably low in natural speech (compare the 837 sC-initial words observed in approximately 30 hours of teacher talk with the 1003 tokens collected in nearly eight hours of sociolinguistic interview – see forthcoming section 5.2; see also Kirk and Demuth 2005 for the probabilistic distribution of

complex onsets and codas in child-directed speech). The selection of the words for inclusion in the study followed four criteria: (1) motivated by the notion that certain prominent positions (e.g. stressed syllables) are more likely to maintain contrasts and thus less likely to undergo phonetic changes (e.g., Beckman 1998, Trubetzkoy 1939), the words selected for the interviews were all monosyllabic (and consequently stressed) to ensure that the clusters under investigation occurred exclusively in positions of prominence; (2) accordingly, the words represented in the pictures had to conform to a sCV(X)(C) syllable shape (where X stands for either a coda consonant – e.g. [p] in sto[p] – or the second element of a tense/long vowel or diphthong – e.g. [j] in sn[ejk]); (3) they had to be highly frequent in English (i.e., within the 1,000 list of the most frequently-used words in the corpora consulted, or highly frequent in the student-directed speech corpus collected) in order to minimize word-frequency effects (Bybee 2001, Flege et al. 1996, Vitevitch et al. 1997): One could argue, for instance, that learners are more likely to produce the cluster correctly in more frequently-occurring words (see also Almeida, Knobel, Finkbeiner and Caramazza (in press) for the effect of word frequency in picture naming tasks); and finally, (4) to diminish the effect of L1 transfer, the words depicted in the pictures could not be words that had been borrowed into Portuguese or used in popular brand names.

The ten participants were post-pubescent (five male and five female) native BP speakers, with an average age of 23. The participants were divided into two groups based on their proficiency in English: (1) Low Intermediate, consisting of six students with an average of 70 hours of classroom experience learning the language; and (2) Advanced, composed of four participants with more than 200 hours of in-class exposure to English. The data were collected by the author at a private language school in the city of Belém, Brazil, where English is rarely used outside of the learning environment. The interviews were audio recorded via a Marantz Flash Recorder PMD660 and an Audio-Technica AT831b lavalier microphone, and were later transcribed using Transcriber (version 1.5.1) and, whenever needed, Praat for more refined speech analyses. Two research assistants assisted me in these tasks. The 1,003 tokens collected were coded according to the variables listed in Table 3, which were then submitted for statistical analysis.

Table 3: Factor Groups for Goldvarb X Analysis

Factor Groups	1	2	3
Dependent Variables	sC	Prothesis	
Proficiency	Low Intermediate	Advanced	
Type of Task/Style	Formal (careful reply)	Less Formal (first reply)	Informal (interview with pictures)
Sonority Profile	/st/	/sn/	/sl/
Participants		1-10	

5.2 Goldvarb Statistical Results and Conclusions

For the statistical analysis of the BPE corpus, we adopted Goldvarb X (Sankoff et al. 2005), a statistical package exclusively designed to handle the types of data derived from studies of language variation, which are characterized by unbalanced data (see Cedergren and Sankoff 1974 for an introduction to this statistical analysis technique for linguistic investigation, and Bayley and Preston's 1996 volume on the application of Goldvarb to variationist L2 acquisition). Briefly, the results of a typical Goldvarb analysis should be interpreted as holding over the entire corpus that is being investigated and, to the extent that this is a representative sample, to all similar speakers and linguistic and extralinguistic contexts. The output of a typical VARBRUL analysis contains the following information: (1) The raw number and the percentage of rule application involving each factor; (2) The factor weight, which measures the influence of each factor in the process under investigation, based on the corpus analyzed and, therefore, provides the most accurate view of the likelihood of variant occurrence. It consists of a list of values associated with each factor independently of others in the same factor group, which indicates the degree to which a factor promotes the occurrence of each variant (see the final results in Table 4). Because the development of sC clusters consists of two variants (sC and prothesis), the factor weight of .5 or higher enhances the likelihood of that variant or factors to have a positive effect on the phenomenon; and finally, (3) the input probability (or Overall Tendency), which is the likelihood that the variable under investigation (sC production in the context

of our study) has of occurring in general, regardless of the specific contribution of the other factors included in the investigation. The final Goldvarb results of the study are illustrated in Table 4 (significant factors are shaded for illustrative purposes and the parenthetical information illustrates the percentage of target-like sC production), where the significant effects of the independent variables *proficiency* and *sonority profile* on the production of sC clusters in BPE are shown.

Table 4: Likelihood of sC Production – Significant Results

Factor Groups		Factors	
Proficiency	Low Intermediate	Advanced	
	.38 (34.9)	.68 (64.9)	
Sonority	/st/	/sl/	/sn/
	.39 (37.3)	.61(56.8)	.54 (50)
Input Probability		.47	

Chi-square/cell 0.070

Note that the factor group *participants* was excluded from the final statistical analysis to prevent interference with the significant *proficiency* factor, since every participant inherently belongs to a proficiency group and, more importantly, because the distribution of sC sequences across the ten participants (see Figure 3) show a very low level of inter-proficiency variation. Ignoring the unexpected behavior of informant 5 (a low intermediate participant whose production mimics that of the advanced learners), accurate sC production is only favored in the speech of advanced learners (participants 7 through 10). These results also confirm the aforementioned variationist view that language is the property of the community and “the individual doesn’t exist as a unit”. Surprisingly, another factor group that was removed from the final Goldvarb analysis was *type of task/style*, since the weights obtained for the two tasks encompassed by the group (around .5) indicate that they have no effect on variable sC production. Accordingly, this factor group was discarded in both stepping-up and stepping-down runs of Goldvarb.

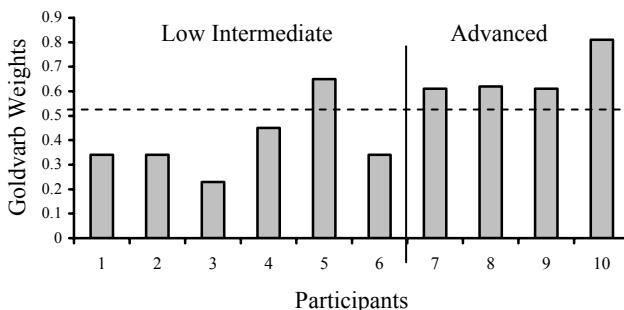


Figure 3: The Distribution of sC Cluster Production across 10 participants

The significant Goldvarb results in Table 4 indicate a very good fit between the model of variation and the data collected. More importantly, they show that the production of sC sequences is favored in the speech of more advanced learners, and when the sC cluster is /sl/ or /sn/ (.61 and .54 respectively). Figure 4 below summarizes the results of the effect of sonority on the development of sC clusters.

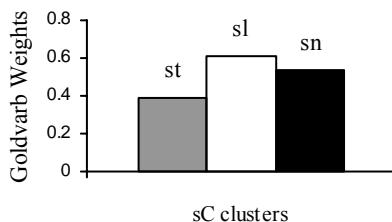


Figure 4: sC cluster Production in BPE

Comparing the results in Figure 4 with the predictions made by both markedness on sonority sequencing (14a) and the frequency of sC clusters in the input (14b), it is clear that the learning path to the development of these clusters mirrors the one predicted by markedness: The least marked (and less frequent) /sl/ and /sn/ sequences are acquired before the most marked (and considerably more frequent) /st/ cluster. In contrast to Bardovi-Harlig's (1987) claim that input frequency can overrule the relative difficulty of learning marked features, the results presented here portray the exact opposite.

(14) Developmental order of sC clusters: Two hypothetical learning paths

- | | | | | | |
|-----------------------|----|---|----|---|----|
| a. Markedness effect: | sl | > | sn | > | st |
| b. Frequency effect: | st | > | sl | > | sn |

In sum, the results above unambiguously show that the frequency of English sC forms in the speech that surrounds the L2 learner has no effect in predicting the development of sC clusters. They do not suggest, however, that frequency should be refuted as a tool to analyze language acquisition and related phenomena – the evidence in support of frequency effects is uncontested, as was discussed in section 4. Along the lines of Ellis (1994), Goldschneider and DeKeyser (2001), and Gass and Mackey (2002), we suggest instead that explaining second language developmental phenomena is a complex task, one whose outcome is mediated by a variety of factors that include L1 transfer, perceptual salience, articulatory complexity, phonetic or allomorphic regularity, and frequency. We take the liberty to add the concept of markedness to this list.

6 Conclusions

This study examined the effects of two hypotheses for the development of English homorganic sC onset clusters in BP-based interlanguage: Markedness on sonority sequencing and sonority distance (Selkirk 1984, Clements 1990), and input frequency (e.g. Bybee 2001, 2007). While the markedness hypothesis predicts that acquisition should progress from the least marked to relatively more marked structures (i.e. /sl/ > /sn/ > /st/), the distribution of these clusters in the input (the frequency hypothesis) predicts that the developmental order will be the reverse (i.e. /st/ > /sl/ > /sn/).

For the assessment of these two hypotheses, two studies were conducted: The first study consisted of the organization and analyses of a corpus of student-directed speech (teacher talk) of an English teacher in a standard language classroom, which served as a characterization of the input. The second study consisted of a cross-sectional, variationist investigation involving the participation of ten of the same students who had “participated” as students in the first study. The results of a multivariate statistical analysis via Goldvarb showed that sC clusters develop as a function of increased proficiency and, more importantly, they clearly indicate that the development of sC clusters follow a path similar to that predicted by the markedness hypothesis.

The study concluded by acknowledging that there are possibly other variables at play in explaining the developmental outcome of sC sequences in interlanguage:

Perhaps the safest conclusion is that input frequency serves as *one* of the factors influencing development, often in association with other factors such as L1 transfer and communicative need.” Ellis (1994:271, emphasis in the original version).

In this particular study, however, input frequency was not *one* of the factors influencing the development of English sC clusters in BP-based interlanguage.

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