Brazilian Learners' Production of Initial /s/ Clusters: Phonological Structure and Environment

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1. Introduction

The acquisition of a foreign or second language can be a difficult and intriguing task, especially concerning the acquisition of certain pronunciation patterns. As a matter of fact, that can be easily noticed in EFL and ESL classrooms, where many students reach the point of native-like competence in grammar and lexicon, but few of them will reach the same competence in pronunciation.

There are some constraining factors on the acquisition of a native-like pronunciation in a foreign or second language. Leather and James (1996) mention some constraints: motivation, social acceptance and social distance, personality variables, sex, and oral and auditory capacities. Thus, the more the learner is concerned with the achievement of a "good" pronunciation the more successful s/he is likely to be. The authors, citing Abercrombie (1963), state that " for the majority of school and non-specialist adult learners, a reasonable goal is to be 'comfortably intelligible' and to sound socially acceptable" (Leather & James, 1996:270).

Besides the individual and social constraints pointed out by Leather and James (1996), there are also some internal factors that are responsible for the occurrence of certain linguistic variants in the learner's interlanguage[1]. As internal constraints, Carlisle (1994) points out *markedness* and *environment.* According to Eckman (1991), investigators have followed two linguistic theories in the study of second language acquisition (SLA). One of them is to explain SLA through typological universals, whose basis of formulation is the world's primary languages, and the other one is through principles of Universal Grammar (UG), which explain facts about the acquisition of a first language and can be used to explain facts regarding the acquisition of a second language.

This article is based on a research which was concerned with the production of the pronunciation of initial /s/ clusters by Brazilian EFL learners, having as a pre-established hypothesis that the environment preceding the initial /s/ clusters plays a special role in the hierarchy of difficulty of their pronunciation. Carlisle (1994) demonstrated in his study that epenthesis is a common strategy used by Spanish-speaking ESL learners trying to pronounce initial /s/ clusters. He also schematized a hierarchy of difficulty in which epenthesis would be more or less likely to occur, depending on the environment preceding that cluster.

Important studies done with Brazilian EFL learners on the production of English initial /s/ -clusters were carried out by Rebello (1997a, 1997b) and Rauber (2002). The data were analyzed "based upon universals of syllable structure, strength relations within the syllable and syllable contact (Hooper, 1976; Murray & Vennemann, 1983) with the Markedness Differential Hypothesis (MDH) and the Structural Conformity Hypothesis (SCH) (Eckman, 1977; 1991) as the predictors of learner's difficulties" (Rebello, 1997:336).

One of the reasons for the research was that Rebello's and Rauber's findings were quite different from Carlisle's concerning the preceding environment: Rebello's and Rauber's results contradict those of Carlisle (1991,1994), who found the frequency of epenthesis to be

[1] The language actually spoken by the learner at any particular stage of development.

greater after word-final consonants than after word-final vowels. Another important difference is related to the length of the cluster: there was no significant difference[2] in percentage in the frequency of epenthesis for /sC/ clusters and /sCC/ clusters in Rebello's study, while in Rauber's and Carlisle's findings the results support the MDH; that is, longer clusters are more frequently modified. Besides that, in Carlisle's study epenthesis was found to happen less frequently before the initial /s/ + nasals and liquids than before /s/ + stops, whereas in Rebello's it was the opposite.

2. Review of literature

For those who have little or no knowledge of what learning a language means, this process is most commonly seen as a task of memorizing words and their corresponding sounds, and placing them in a "correct way" in order to communicate ideas. From this simplistic perspective, we can perceive two important views of what learning a language may involve. First, people have intrinsically the notion of rules. You do not only put words together, but they have to come in a permissible structure so that they are able to express logical thoughts. Second, a language consists of units, that is, people in general understand that the words are the units of a language.

When we think of expressing thoughts, this can be done in at least two forms, written and oral. For the purpose of this study, oral speech discourse is the medium that will be the object of analysis. Kreidler (1989:6) states that a discourse is composed of utterances, which are composed of tone units. He also states that "a tone unit consists of at least one SYLLABLE and usually a number of syllables." For a phonological study, which is the aim of this thesis, it is of primordial importance to understand the structure of a syllable in its universal aspects, as well as the aspects of the languages that are object of this study. As Kreidler (1989) points out, the syllable consists of a vocalic element(s), with the possibility of non-vocalic element(s) before and after it.

It is a very hard task to try to define the *syllable* because there is not a single definition agreed upon among phonologists. What we can do is to analyze some aspects concerning the syllable. It can be compared to an atom, which is the smallest particle of a chemical element and yet divided into smaller parts internally. For phonological purposes, the syllable is the smallest pronounceable part of words. It can be a word itself. Nevertheless, syllable structure contains internal segments. Major (2001) states that all languages have syllables composed of consonants and vowels and that a lot of languages can have syllables of only vowels, otherwise only a very few languages can have syllables and even whole words composed exclusively of consonants.

Among the possibilities of syllable formation, the universally preferred structure is CV. Carlisle (1994:226) states that "this syllable type is an absolute substantive universal, and the presence of any other syllable type implies the presence of the CV syllable." Therefore, it is a typological universal and also the most basic level of an implicational hierarchy of syllable formation. According to Hooper (1976:199), "on a universal level, the CV syllable is the optimal syllable. There is no language that does not allow a syllable type CV, and there are some languages that allow this type and no other." Corroborating the above statements, Major (2001) points out that a VC type syllable implies CVC and CV syllables, but the opposite is untrue.

Katamba (1989) claims that many languages have syllables with only a V. Such languages may be assumed to have a rule at the entry to the phonological component which deletes the syllable initial C and thus allows canonical syllables with V only. Languages may

[2] An statistical test (chi-square) was applied using her numbers to get this conclusion.

also have CVC syllables which are obtained by a rule which adds a C after the V element to form canonical CVC syllables (Katamba, 1989:160).

Hooper (1976) points out that there are many other complex syllable structures besides the favored CV. There are syllable-initial and syllable-final consonant clusters of different lengths in different languages. The length of the syllable does not happen in a random manner. According to Hooper (1976), strength relations influence syllable formation and the possible consonantal positions in a syllable. *Strength* and *sonority* are inversely related compared on a scale of values. For the purpose of this thesis, *strength* refers to the manner of articulation, the strongest consonant sound being the one which most obstructs the air stream, so we could say that voiceless stops are the strongest consonant sounds, and glides the weakest ones. *Sonority*, then, is related to voicing: "the greater the propensity a sound has of spontaneous voicing, the more sonority it has" (Katamba, 1989:104). Contrastively, in a sonority hierarchy, vowels and glides are the most sonorous while the voiceless stops are the least sonorous.

While Natural Generative Phonology may have been the first phonological theory to give due importance to the syllable, two recent models describe the syllable in a non-linear approach: the autosegmental and the metrical. Katamba (1989) reports that metrical phonology, which is concerned principally with stress phenomena, complements autosegmental phonology, which was originally conceived for the description of tone. As the two concepts are not diverging, they will be helpful for understanding the strength relations in syllable structure described by Hooper (1976), within the theory of Natural Generative Phonology.

Hooper (1976:198) points out that as a universal position, the nucleus of the syllable is the dominant part and is usually a vowel. She adds that "the margins of the syllable (the onset and the coda) provide a contrast with the nucleus: The consonantal release produces the minimum amount of energy and the vocalic nucleus the maximum amount of energy." We can conclude that the higher the sonority (the more vowel-like) of a consonant, the closer to the nucleus it is expected to be.

Based on her universal strength hierarchy, Hooper (1976:229) proposes the universal SSC (syllable structure condition) as follows:

Universal condition on preferred syllable structure:
P (C): $\$C_mC_nC_pC_qVC_rC_sC_t\$$
Where $m > n > p > q$
$r > s > t$ [sic][3]
$m > t$
$m > ø$

Since the nucleus is the most sonorous part of the syllable, the consonants are usually placed in a descending order from the edges to the nucleus, regarding the strength value (or ascending order, regarding sonority). "The condition m > t means, in this context, that for the SSC of any given language, the strongest C permitted in syllable-initial position must be stronger than the strongest C permitted in syllable-final position" (Hooper, 1976:230). And the condition m > ø means that the structure CV is present in any given language. In general, most languages follow this principle, although we will find a few cases of languages that violate it for a particular motivation. An example is the English /s/ + stop clusters. Selkirk (1984:116) names this condition the *Sonority Sequencing Generalization* (SSG): "In any syllable, there is a segment constituting a sonority peak that is preceded and/or followed by a sequence of segments with progressively decreasing sonority values." As can be noticed,

[3] The arrows should be pointing toward the opposite direction.

some languages allow long consonant clusters in initial position and in final position. Arbitrarily, Hooper (1976) decided for an example of four consonants in initial position and three in final position to demonstrate her SSC.

Greenberg (1965) presents, in his universals regarding initial and final clusters, the property of resolvability, which is particularly important to observe in the structure of syllables. Greenberg (1965:250) states that "every initial or final sequence of length $\underline{m}$ contains at least one continuous subsequence of length $\underline{m - 1}$". The resolvability can be complete or partial. It is considered completely resolvable if every continuous subsequence also occurs, for instance, if in a language the initial cluster /spgr/ occurs, then it will be completely resolvable if /sp/, /pg/, /gr/, /spg/, and /pgr/ also occur. If one or more of these do not occur, then it is partially resolvable, and if none occurs, it is non-resolvable.

According to the structure proposed by Selkirk (1982), the syllable is composed of the *onset* and the *rhyme*. A consonant or consonant cluster placed at the beginning of the syllable forms the *onset* and the rest of the syllable is the *rhyme*, which is divided into two parts: the *peak* and the *coda*. The peak or nucleus is the syllabic part and the coda is the final consonant or consonant cluster.

English Syllable Structure allows up to three onset consonants and up to four coda consonants (Anderson, 1987). As the initial clusters are the concern of this study, I will present some considerations regarding the onset. Giegerich (1992) states that syllables do not need to have onsets and if there is an onset, it may contain one consonant position or two. Three consonant positions in the onset give some ill-formed syllables. "The two-position onset constitutes some kind of upper limit on the complexity of this phonological unit" (Giegerich, 1992:138). However, what can be said about the well-formed syllables in the words *spray, strange, screen*? In Giegerich's (1992:138) point of view, the /s/ in /st/, /str/, among others has an odd behavior as "it violates the sonority-based definition of the syllable," and where there are three consonant positions in the onset, the /s/ will always be the first one.

Adapting Hooper's (1976) SSC to English syllable structure, the following schema would be possible: $\$C_mC_nC_pVC_qC_rC_sC_t\$$. There will be always a vowel (or in some cases a sonorant consonant), which is the nucleus. English syllables allow longer consonant clusters in final position than in initial position. From this perspective, it is possible to state that English codas have a more marked structure than English onsets. Here, besides the consideration regarding the strength scale, whose values would decrease from the edges to the nucleus (or the sonority scale, whose values would increase from the edges to the nucleus), it would be important to remark that, according to Giegerich's (1992) claims, C_m must be /s/.

Brazilian Portuguese syllable structure follows more closely the universal tendency for a CV syllable formation. It does not allow more than two consonants in initial and/or final positions, and very few consonants can occur in final position or in clusters.

Baptista (1987) proposes a distribution chart concerning strength relations in Portuguese based on those described by Hooper (1976) for Spanish. According to Baptista (1987), Portuguese allows up to two consonants in syllable initial and final positions:

$$\$C_mC_nVC_pC_q\$$$

C_m1 = /p, t, k, b, d, g, f, v/ = initial, may be followed by C_n
C_m2 = /s, ʃ, z, ʒ, m, n, ŋ, l, ʎ, r, ɾ/ = initial, may not be followed by C_n
C_n = /r, l, w/ = may follow C_m1 (/w/ follows only /k/ and /g/)
C_p = /y, w/ = may follow V; may be followed by C_q1 (as in Spanish, /r/ occasionally occurs in this position)
C_q1 = /s/ = may follow V and/or C_p
C_q2 = /s, m, n, l, r or ɾ/ = may follow V (/m/, /n/, and /l/ are doubtful in this position).

However, Baptista's (1987) analysis does not account for word-internal occurrences of syllable-final nasal plus /s/ or /r/ plus /s/.

Besides being concerned with syllable structure, it is important to be aware that the words are not all monosyllabic, many of them are polysyllabic and therefore we have to analyze the contact between syllables. This contact may cause odd implications in addition to those related specifically to a single syllable. Hooper (1976:220) claims that a syllable structure condition for syllable boundaries is necessary, stating that "this condition requires that a syllable-initial C be stronger than the immediately preceding syllable-final C […] if XVCr$CmV, and there is no pause between Cr and Cm, then m>r."

As it is my intention to analyze the production of initial /s/ clusters by Brazilian Portuguese speakers who are learning English, it is obviously essential that some theories concerning L2 acquisition be presented here.

The Contrastive Analysis Hypothesis (CAH) has two versions. The first one, named the strong form, had as a principal exponent Lado (1957 cited in Eckman 1977). Basically, he claimed that when learning a second language, the differences between the two languages would predict difficulties for the learner, whereas similar structures would be easy to acquire. The second one, named the weak version, was less predictive and tried to explain the facts after they had happened. In both versions, the idea is that nonnative substitutions are due to transfer: "The exact nature of the substitutions did not matter, because they were unquestionably due to transfer" (Major, 1994:185). Later, the CAH started being put aside, as transfer could not explain all the substitutions or certain phenomena in L2 acquisition and many predicted errors did not occur.

As the CAH, or language transfer only, could not explain all the difficulties in second language acquisition, some other explanation should arise. Eckman (1977) proposes the Markedness Differential Hypothesis (MDH) as follows:

> 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, such that,
>
> a) Those areas of the target language which differ from the native language and are more marked than the native language will be difficult.
> b) The relative degree of difficulty of the areas of the target language which are more marked than the native language will correspond to the relative degree of markedness.
> c) Those areas of the target language which are different from the native language, but are not more marked than the native language will not be difficult. (p. 61)

In order to understand the hypothesis, it is essential to understand Eckman's (1977:60) explanation of *markedness*: "a phenomenon A in some language is more marked than B if the presence of A in a language implies the presence of B; but the presence of B does not imply the presence of A." Thus, speakers of a language (X) whose structure is more marked than a corresponding structure in another language (Y) will have less difficulty in learning the structure of language (Y), while speakers of language (Y) will have more difficulty in learning the structure of language (X).

In an attempt to explain second language acquisition (SLA), some researchers have tried to use primary language acquisition as a parameter. It is helpful to know whether secondary language holds some of the same principles as the primary language. Some typological universals have been formulated to explain facts about SLA. To test if interlanguage conforms to universal generalizations, Eckman (1991:24) has postulated the Interlanguage Structural Conformity Hypothesis (Interlanguage SCH), which states that: "the universal generalizations that hold for primary languages hold also for interlanguages." He

justifies the hypothesis in the claim that (1) interlanguages are languages, and (2) 'universal' means that all human languages are influenced by the universal generalizations. Compared to the MDH, Eckman claims that the Interlanguage SCH is stronger because it is more easily falsified. The author also states that the Interlanguage SCH is more explanatory than MDH.

It is recognized by researchers that errors in the phonology of a second language can be attributed to negative transfer or to developmental factors. The Ontogeny Model proposed by Major (1986a) claims that the errors due to transfer processes decrease while errors due to developmental processes increase and then decrease over time. In other words, for the less proficient learners at beginning levels of learning a second language, transfer errors will be more present than developmental errors. The tendency is that the former decrease chronologically, but not necessarily implying the increase of correct performance because the latter start becoming more apparent. More proficient learners will have a higher percentage of developmental errors than transfer errors in their interlanguages. However, this kind of error also decreases chronologically up to a certain point, where the level of correct performance is higher.

3. Method

Brazilian Portuguese speakers and Spanish speakers who learn English may use, in their interlanguage phonology, some strategies in order to produce what for them is a possible target pronunciation. One of these strategies noticed by investigators is the insertion of an epenthetic vowel before the English initial /s/ clusters, as this type of cluster is not permitted in either of these two languages. I have tried to answer some questions related to the variation in frequency of use of this strategy in different phonological structures and environments.

The first question to be investigated was whether the length of the cluster, that is, the difference between /sC/ and /sCC/, would be a factor influencing the frequency of production of epenthesis by Brazilian learners of English. According to the CAH, the acquisition of the two lengths of /s/ clusters would be difficult since they do not occur in the native language (Portuguese). The MDH, however, leads to a more specific hypothesis: that the /sCC/ clusters would yield a higher rate of epenthesis, as this is a more marked structure.

The second question to be investigated was whether the sonority relationship within the cluster would influence the frequency of epenthesis by the learners. Here it is imperative to remember that the /sC/ cluster where C is a STOP violates the SSC proposed by Hooper (1976), since the stops are stronger (less sonorous) than the /s/ (a FRICATIVE). The /sC/ cluster where the second element is a sonorant, on the other hand, does not violate the SSC, since the liquid /l/ and the nasals /m, n/ are weaker (more sonorous) than the fricative /s/. Therefore, the hypothesis was that the /s/ + stop would yield a higher rate of epenthesis than the /s/ + sonorant because of this violation.

The third question to be investigated was whether the Brazilian tendency to voice the /s/ of /s/ + sonorant clusters would influence the frequency of epenthesis by the learners.

The fourth question to be investigated was which environment preceding the initial /s/ cluster, that is, consonant or vowel, would cause the Brazilian EFL learners to produce epenthesis more frequently. Carlisle (1994) found that with Spanish speakers, a consonant in the environment caused more epenthesis than a vowel. However, two other studies carried out with Brazilian Portuguese speakers (Rauber, 2002; Rebello, 1997) arrived at a different and rather surprising outcome: the Brazilian learners produced a higher rate of epenthesis in /sC/ clusters preceded by vowels than in clusters preceded by consonants. Based on the latter studies, the hypothesis for this research was that the Brazilian Portuguese learners would show a tendency to produce epenthesis more frequently in clusters preceded by a vocalic context.

The data analyzed were collected among students from (a) two different university undergraduate courses: four Administration students with a major in Foreign Trade and ten International Relations students, all from UNIVALI – Universidade do Vale do Itajaí – Campus VII, São José, Santa Catarina; and (b) two different language schools in Florianópolis, Santa Catarina: three from CNA (Instituto Cultural Norte Americano), and three from SLES (Special Language and Educational Service), both located in the center of Florianópolis. The students from UNIVALI were chosen because they have English as part of their curriculum and the classes involve the general study of the language, developing the four main skills (listening, speaking, reading and writing). The participants were chosen from among those students who were classified as lower-intermediate, intermediate and upper-intermediate, based on an interview conducted with them by the researcher, who was also the teacher of all but the CNA students. Beginners were not included in the study because they would probably have difficulty in reading the material.

The material to be read consisted of a list of sixty-five topically unrelated sentences, forty-four of them containing initial /s/ clusters borrowed from Rebello (1997), and twenty-one of them serving as distractor sentences. For each cluster /sp, st, sk, sm, sn, sl, spr, spl, str, skr, skw/, there were four sentences, two containing a vowel in the preceding environment, one a stop, and one a fricative.

The participants were recorded reading the sentences in random order, as they were printed on separate strips and were picked up out of a box. Transcriptions of the target words and the preceding context word were made by the researcher and later independently by a second rater. After that, both listeners met to listen to the material again where there had been discrepancies and decide whether or not epenthesis had actually been produced. From a total of 880 sentences assumed to be recorded and analyzed, one was not read, thirty-nine were eliminated for having been misread, and two were eliminated because of continued disagreement between the transcribers.

Since my objective was to look at frequencies of some predetermined variables, an appropriate statistical test was applied, the Chi-square (X^2); with this test it is possible to make claims with some degree of certainty.

4. Results and discussion

Regarding the participants divided by proficiency level, the production of epenthesis was much higher for the group consisting of lower-intermediate and intermediate participants (group 1) (72.55%) than for the group consisting of upper-intermediate participants (group 2) (41.01%), which resulted in a very significant chi-square (X^2 (1, N = 837) = 83.55, $p < .0001$). This result supports Major's (1986a) Ontogeny Model, in which he claims that errors due to transfer decrease chronologically.

Results in relation to the participants' total production of epenthesis for all /sC/ and /sCC/ clusters varied from 13.95% to 88.09%. The average production of epenthesis for all the participants was 58.30%. This result is compatible with Rebello's (1997a, 1997b) results. However, Rauber's (2002) total result for all the Brazilian participants was only 33.02%, a considerably lower percentage compared to the other studies. This may be explained by the level of the subjects invited to participate in the research. The subjects invited to participate in the present study and in Rebello's were probably less fluent in the target language than those of Rauber's study. In Rauber's study the participants were not only EFL learners, but also undergraduate students of a "Letras" course and may have had *Phonetics* and *Phonology* as subjects in their course.

As an overview of the results, the participants produced an average rate of 50.00% of epenthesis in bi-literal clusters in violation and 57.66% of epenthesis in tri-literal clusters.

Although these results show a difference of 7.66%, this difference did not prove to be statistically significant using the chi-square test (X^2 (1, N = 617) = 3.13, p > .05). Even separate calculations by proficiency level failed to yield significant results, although longer clusters yielded higher rates of epenthesis in both groups**.**

Intermediate and lower-intermediate students produced 62.20% of epenthesis for bi-literal clusters in violation and 71.70% of epenthesis for tri-literal clusters, a non-significant chi-square (X^2 (1, N = 339) = 2.87, p > .05). Upper-intermediate students produced 35.24% of epenthesis for bi-literal clusters in violation and 40.46% of epenthesis for tri-literal clusters, a non-significant chi-square of (X^2 (1, N = 278) = .55, p > .05). Furthermore, some participants produced more epenthesis in bi-literal clusters. Again Major's OM is significantly supported by the results. On the other hand, the MDH is not supported by the results: the longer clusters did not yield a significantly greater rate of epenthesis than the shorter ones.

The results corroborate Rebello's (1997a, 1997b) findings. Calculating the totals of Rebello's (1997a:66) results comparing the groups of /sC/ clusters (in violation) and /sCC/ clusters, we find rates of epenthesis production of 54.43% and 54.90% respectively, which will certainly result in a non-significant chi-square. However, Rauber's (2002) results diverge, as she found a very significant chi-square regarding the difference between /sC/ clusters in violation and /sCC/ clusters, with a higher rate of epenthesis for the latter. Analyzing the three studies, the hypothesis regarding the production or acquisition of initial /s/ clusters remains without conclusive support or rejection, as the results do not follow converging directions and no prediction was consistently supported. Possibly the length of cluster makes a greater difference for students at a more advanced level, who produce a lower frequency of epenthesis.

Just as it was not methodologically sound to analyze bi-literal clusters not in violation versus tri-literal clusters regarding length (since all of these are in violation), it is essential to analyze bi-literal clusters not in violation of the SSC (/sm/, /sn/, and /sk/) in comparison only with bi-literal clusters (not tri-literal) in violation (/sp/, /st/, and /sk/) to investigate whether the sonority within the clusters influences the rate of epenthesis.

The total rate of epenthesis was higher for /s/ + sonorant clusters (68.18%) than for /s/ + stop clusters (50%). The difference was 18.18%, which yielded a very significant chi-square (X^2 (1, N = 452) = 14.67, p < .0005). The results corroborate neither the SSC nor Rauber (2002), who reported the production of 30.89% of epenthesis for bi-literal clusters in violation versus 27.57% of epenthesis for bi-literal clusters not in violation. This difference of 3.32% was not found to be significant, and the author pointed out that four participants out of ten produced more epenthesis for bi-literal clusters not in violation than for bi-literals in violation and suggested that the effects of markedness by sonority may have been neutralized by the effects of markedness regarding voicing.

On the other hand, the results corroborate Rebello (1997a, 1997b), who reported a rate of epenthesis of 63% for bi-literal clusters not in violation and 54% for bi-literal clusters in violation, a difference of 9%, but with no statistical tests to prove significance.

Regarding the level of proficiency, we can notice that in percentages both groups produced a higher rate of epenthesis in /s/ + sonorant clusters than in /s/ + stop clusters, but only one group's results were significant, group 1, the least proficient students (LI/I). This group obtained a rate of 62.20% of epenthesis in /s/ + stops clusters and 85.00% in /s/ + sonorant clusters, which resulted in a very significant chi-square (X^2 (1, N = 247) = 15.23, p < .0001). Although group 2, the most proficient (UI), obtained a rate of 35.24% in /s/ + stop clusters and 48.00% in /s/ + sonorant clusters, it resulted in a non-significant chi-square (X^2 (1, N = 205) = 2.93, p > .05). It should be pointed out that three of the five participants who did not follow the general tendency were from the more proficient group and one of them had the lowest rate of epenthesis of the less proficient group.

Anyway, voicing assimilation seems to be a more powerful constraint for Brazilian Portuguese speakers than the SSC. In studies that dealt with Spanish speakers (Carlisle, 1994; Rauber, 2002), a significantly higher rate of epenthesis was found in /s/ + stop clusters than in /s/ + sonorant clusters. Since in Spanish the voiced fricative /z/ does not occur, voicing assimilation does not exist as a constraint in Spanish-English interlanguage, thus allowing the SSC to act more powerfully. This explanation can enlighten the difference between the more and less proficient groups of Portuguese speakers. It seems that as a Portuguese speaker becomes more proficient in English, the occurrence of voicing assimilation may decrease, which may cause the rate of epenthesis to decrease in /s/ + sonorant clusters. Again Major's OM is supported by the results, as the errors provided by negative transfer decrease chronologically while the learner's proficiency continues to develop.

Contradicting the SSC, the /s/ + sonorant clusters produced a higher rate of epenthesis, in this study, than /s/ + stop clusters, as discussed in the previous section. Thus, a comparison between /s/-nasals (/sm/ and /sn/) and /s/-liquid (/sl/) was made in order to investigate whether markedness regarding sonority would make the right prediction in this case and to verify the influence of voicing assimilation on the epenthesis rate of /s/ + sonorant clusters. The third hypothesis was that the tendency of Brazilian Portuguese speakers to voice the /s/ in /s/ + sonorant clusters might cause the frequency of epenthesis to increase. The explanation for this expectation is that the resulting voiced obstruent + sonorant sequence is more marked than a voiceless obstruent + sonorant.

It is noticeable that the frequency of epenthesis was much higher for /s/-nasals (74.50%) than for /s/-liquid (53.52%), which resulted in a very significant chi-square (X^2 (1, N = 220) = 8.74, $p < .005$). If Hooper's (1976) SSC failed in predicting a higher rate of epenthesis for /s/ + stops than for /s/ + sonorants, its prediction was correct concerning the comparison of /s/-nasals versus /s/-liquid, since nasals are stronger than liquids in the universal strength hierarchy. Studies carried out by Carlisle (1992) and Rebello (1997a, 1997b), with Spanish and Portuguese speakers respectively, also report that obstruent + nasal onsets resulted in more epenthesis than obstruent + liquid. However, Rauber's findings showed a very insignificant difference between /sN/ (36.80%) and /sl/ (36.59%) clusters by Portuguese speakers.

We could see that the percentage of voicing of /s/ was very high in both types of clusters, 71.81% in /s/-nasal and 67.61% in /s/-liquid, in both cases possibly due to assimilation. This explanation is supported by the extremely significant difference between the rates of epenthesis where the sibilant was voiced (88.79%) and where the sibilant was not voiced (38.10%) for /s/-nasal clusters, resulting in a significant chi-square (X^2 (1, N = 149) = 38.17, $p < .0001$), and the extremely significant difference between the rates of epenthesis where the sibilant was voiced (70.83%) for /s/-liquid and where the sibilant was not voiced (17.39%) for /s/-liquid clusters, also resulting in a very significant chi-square (X^2 (1, N = 71) = 15.77, $p < .0001$). Thus, the results strongly support the hypothesis that voicing assimilation is responsible for the higher rate of epenthesis production before /s/ + sonorant clusters and corroborate both Rebello and Rauber in this regard.

Phonological environment proved to be an important constraint influencing the production of epenthesis as reported in studies by Carlisle (1991, 1992, 1994), Rebello (1997) and Rauber (2002). Carlisle's studies reported that Spanish EFL speakers produced epenthesis more frequently in /sC/ clusters preceded by word-final consonants than in those preceded by word-final vowels.

The participants showed a tendency to produce epenthesis more frequently after a vocalic context (68.29%) than after a consonant context (43.55%), which resulted in a very significant chi-square (X^2 (1, N = 718) = 43.61, $p < .0001$). In a comparison between the production of epenthesis in /sC/ clusters preceded by vowels and preceded by consonants, all the participants show more frequency of epenthesis in onsets preceded by vowels, confirming,

thus the fourth hypothesis. Since vowels are voiced, perhaps this result is also influenced by the voicing assimilation, as the results show that voiced obstruents yield a higher rate of epenthesis than voiceless obstruents.

Examining the frequency of epenthesis in initial /s/ clusters in the environment of voiced and voiceless obstruents, the rates were twice as high in the voiced context (59.65%) than in the voiceless context (28.25%), resulting in a very significant chi-square (X^2 (1, N = 348) = 33.59, $p < .0001$). Voicing again proves to be a very strong variable constraint inducing the insertion of an epenthetic vowel.

As reported, the corpus consisted of unrelated utterances containing initial /s/ clusters preceded by three different environments: for each cluster two sentences with vowels, one sentence with a fricative, and one sentence with a stop. So far, it has been found that vowels in the preceding environment induced a higher rate of epenthesis than consonants, and voiced obstruents a higher rate than voiceless obstruents. Among the obstruents, it is still essential to analyze the frequency of epenthesis in initial /s/ clusters in the two different consonant contexts: fricatives and stops.

Fricatives caused more frequent epenthesis (53.21%) than stops (35.60%), a difference of 17.61%, which resulted in a very significant chi-square (X^2 (1, N = 347) = 10.12, $p < .005$). This result, added to the result that voiced obstruents in the environment induced more frequent epenthesis than voiceless obstruents, leads to the suggestion that the strength of the environment consonant seems to be acting as an important constraint: the stronger (the less sonorant) the consonant in the preceding context of the initial /s/ clusters, the smaller the influence in the production of epenthesis. It is worthwhile to mention Baptista and Silva (1997)'s results concerning epenthesis after final consonants: more after voiced than voiceless obstruents and more after labiodental fricatives than after stops (interdentals were not included in that study because of articulatory difficulty and sibilants should not be considered in this comparison because they are permitted in final position in Portuguese).

Another important factor judged to influence the production of epenthesis was the feature [± sibilant] in fricatives. The results show a higher frequency of epenthesis in initial /s/ clusters in the context of [+ sibilant] fricatives (63.64%) than in the context of [- sibilant] fricatives (39.13%), resulting in a very significant chi-square (X^2 (1, N = 157) = 8.36, $p < .005$).

Nevertheless, once again the two groups obtained different significance scores, although the rate of epenthesis was higher in the context of fricatives [+ sibilant] for both groups. Group 1 produced an epenthesis rate of 78.43% in the environment of [+ sibilant] fricatives and 65.79% in the environment of [- sibilant] fricatives, a difference that resulted in a non-significant chi-square (X^2 (1, N = 89) = 1.18, $p > .05$); whereas group 2 produced a frequency of 43.24% in the environment of [+ sibilant] fricatives and a much lower rate of 6.45% in the environment of [- sibilant] fricatives, which resulted in a very significant chi-square (X^2 (1, N = 68) = 9.92, $p < .005$).

The explanation for such results may be that while at a less proficient level, the context of all fricatives seems to impose a certain degree of difficulty regardless of the feature [±sibilant]; as the learner improves in the TL, the constraint acting seems to be the difficulty in pronouncing two sibilants together as one (or the lack of knowledge that this is permitted). The learner seems to feel compelled to pronounce the two sibilants separately and in their entirety, which is only possible with the insertion of a vowel.

To sum up and taking into account the hypotheses formulated, it may be said that: (1) the length of the cluster influenced the production of epenthesis: the participants tended to produce more epenthesis in longer clusters, that is, initial /sCC/, than in shorter clusters, that is, initial /sC/, but the results were not significant enough to claim that this constraint was responsible; (2) the sonority relationship within the cluster influenced the production of epenthesis; however, contrary to the expectation, initial /s/ clusters (/s/ + stop) that violate the

SSC proposed by Hooper (1976) yielded a lower rate of epenthesis than those clusters (/s/ + nasal or liquid) that do not violate the SSC; (3) the tendency of Brazilian learners to voice the /s/ of /s/ + sonorant clusters influenced the frequency of epenthesis; and (4) Brazilian learners produced more epenthesis after a vocalic environment than after a consonant. Also regarding the preceding consonant context, (5) voiced obstruents yielded a higher frequency of epenthesis than the voiceless ones; (6) a fricative environment yielded more epenthesis than a stop context; and (7) a preceding environment with [+sibilant] fricatives produced more epenthesis than a context with [-sibilant] fricatives.

5. Conclusion

The conclusion regarding the first hypothesis, which dealt with the investigation of the length of the cluster, remains unresolved, as it is not possible to state that tri-literal clusters certainly yield a greater production of epenthesis. The statistical analysis gives no support to the MDH, as the results were not significant. What can be inferred, though, is that the higher the proficiency level of the participant, the lower the production of epenthesis, thus supporting Major's OM.

Regarding the second hypothesis, the general results show that /s/ + sonorant clusters caused a higher rate of epenthesis than the /s/ + stop, which goes against the hypothesis, since the prediction was that /s/ + stop clusters would be more difficult because they violate the SSC. A possible explanation for this fact is that the voicing assimilation of the initial /s/ neutralized the SSC and was a more powerful constraint. This can be confirmed as we look at the results of the most proficient group, whose voicing assimilation percentage was lower, consequently resulting in a non-significant difference in the production of epenthesis in the two kinds of clusters.

The conclusion regarding the third hypothesis helps to enlighten the results concerning the second one. Voicing assimilation proved to be a more powerful constraint influencing the production of epenthesis. A very expressive frequency of epenthesis was produced when voicing assimilation occurred, independent of the level of proficiency.

The fourth hypothesis shows differences between Spanish and Portuguese speakers learning English regarding the environment that most influences the production of epenthesis. The three studies of initial /s/ cluster production by Brazilian Portuguese speakers, Rebello (1997a, 1997b), Rauber (2002) and this one, found that a preceding vocalic environment caused a higher rate of epenthesis than a consonant environment. This result is of particular importance, since the studies with Spanish speakers (Carlisle, 1994; Rauber, 2002) show the contrary: greater frequency of epenthesis after consonants. Concerning obstruents as a preceding environment, the voiced ones were responsible for a much more frequent occurrence of epenthesis, showing strong evidence that voicing in the preceding context really influences the insertion of an epenthetic vowel by Brazilian Portuguese speakers. Since vowels are all voiced, this may also explain the greater frequency of epenthesis after vowels by the Brazilian Portuguese speakers. Regarding fricatives versus stops as preceding environment, fricatives were found to cause epenthesis more frequently than stops. These results lead us to the conclusion that the stronger the consonant in the preceding environment, the smaller the production of epenthesis.

In sum, the findings do not give strong support to the MDH; however, they strongly support Major's OM, which suggests that markedness cannot be seen as necessarily the most powerful constraint responsible. Rather, it seems that, at least in the production of epenthesis by Brazilian Portuguese learners, transfer of native language processes can take priority in the early stages of learning.

The conclusion of this study would be useless if it was not possible to extract some pedagogical implications. EFL teachers have often neglected the systematic teaching of pronunciation or phonology. Some of the reasons for that are the following:

(a) Time constraints: Depending on the place where the language is being taught, quantity often prevails over quality, and the teacher is obliged to complete a very demanding curriculum.

(b) Teacher competence: The teacher is not skilled or well enough informed to competently inform his/her students about the sound patterns they have difficulty with or even to propose exercises for them.

(c) Lack of concern: Many teachers do not worry about whether their students' lack of phonological competence is causing any problems in communication.

(d) Lack of proper material for dealing with the subject: It is difficult to find material that informs the way the teaching of pronunciation or phonology should be dealt with in specific L1 environments.

Regarding (d) above, this kind of research is valuable in providing information of how the acquisition and production of specific sounds occur, thus supplying the teachers with reliable and useful information. Concerning specifically the learning and teaching of initial /s/ clusters, some recommendations can be made: (1) EFL teachers and pedagogical materials writers should be aware of how important the notion of voicing is and prepare classes and material which can adequately induce the learners to perceive and produce voiced and voiceless sounds as correctly as possible; (2) in initial /s/ + sonorant clusters the unvoiced pattern of the /s/ should be emphasized; (3) the environment preceding the initial /s/ clusters should be provided following a hierarchy, from the easiest to the most difficult: for Brazilians, first voiceless obstruents, then, voiced obstruents, and at last vowels; (4) when the preceding environment is a sibilant, the learners should be informed that the two sibilants should be pronounced together, otherwise the insertion of an epenthetic vowel will be inevitable.

I did not recommend less marked clusters to be taught before more marked clusters because, as this study shows, more marked clusters do not consistently prove to be more difficult to produce.

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