# On the undecidable syllabification of /sC/ clusters in Italian: Converging experimental evidence

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To Bruce Derwing
the Lord of Humor

## *1. Introduction*

A widespread claim among linguists defines /sC/ clusters as universally heterosyllabic (cf. Kaye 1991, Lamontagne 1993, Van De Weijer 1996).[1] One often cited reason for this is (i) the tendency towards vowel epenthesis in the word initial position, as observed in languages such as Spanish and Old French (cf. Sp. *escuela* and Fr. *école* from Lat. *schola* 'school'). This indicates the need to create a new syllable nucleus, to accommodate an element that cannot fit into the onset. Another reason, whose effects converge with the previous one, is that (ii) /s/ often appears word-finally, suggesting this consonant's easy adaptability to the coda position (cf. Sp. *casas* 'houses' or Eng. *houses*).

Not all languages follow these tendencies. Spanish is an example of a language that complies with both conditions (i-ii), but English does not respect condition (i), despite exhibiting quite a lot of word-final /s/.[2] Modern French, by contrast, has few phonetically realized word-final /s/, and presents a non-negligible share of word-initial /sC/ clusters, side-by-side a number of inherited words with initial epenthesis. Contemporary Italian is similar to French with respect to condition (ii), for it presents relatively few words ending in a consonant apart from the sonorants /r l m n/ (despite the increasing number of consonant-final loanwords and neologisms, including acronyms). By contrast, it definitely does not respect condition (i), for the tendency towards postlexical word-initial vowel epenthesis, which was pervasive in the past, no longer exists (cf. *in Spagna* 'in Spain' as opposed to *in Ispagna*, still found, for instance, in Da Ponte's libretto of *Don Giovanni*).[3]

Despite this fact, a number of scholars have repeatedly claimed that Italian tends towards the allegedly universal heterosyllabicity of /sC/ clusters. Nespor (1993), Marotta (1995a) and Loporcaro (1999) are among the recent defenders of this view. The most detailed anal-

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ysis is Marotta's. Upon close examination, however, none of her arguments turn out to be compelling, as Bertinetto's (1999) detailed counter-analysis shows. In particular, as to arguments deriving from distributional regularities (namely, the vast majority), one can show that data on Modern Italian easily contradict them, although these regularities thoroughly reflect the status of previous stages of the language.

For instance, no one would deny that the historical Italian diphthongization of Latin Ĕ and Ŏ in stressed open syllables was blocked before /sC/ clusters, as the following examples show: *piede* 'foot', *pietra* 'stone', *cuoco* 'cook', *fuoco* 'fire' vs. *testa* 'head', *festa* 'feast', *veste* 'cloth', *posto* 'place', *mosto* 'must'. There is, thus, absolutely no doubt that the clusters under analysis were heterosyllabic at the time when these diphthongs emerged. This argument, however, has no synchronic validity in Modern Italian, since the open syllable diphthongization process is no longer active. This is abundantly shown by the lexicon of Contemporary Italian, which presents inherited words complying with the previously operating constraint alongside words that violate it, especially in verb declension. For instance, all forms of *muovere* 'move' or *spiegare* 'explain' present the diphthong, regardless of stress position. The loss of the diphthongization process, however, did not automatically imply reshaping of the whole lexicon. Significantly, words like *piede*, *pietra* and *cuoco* did not reshape into **pede*, **petra* and **coco*, confirming the view that the lexicon of any language may continue to reflect phonological tendencies operating at previous stages.[4] The described situation is obviously disruptive for generative approaches, due to the capricious behavior of the allegedly underlying vowels /E O/, idiosyncratically diphthongizing in some words, but not in others. This could hardly provide the basis for a sound generalization. If one assumes, by contrast, a non-generative framework, such that the /jE wO/ diphthongs are regarded as underlying wherever they appear, the only way to make sense of the restriction affecting /E O/ before /sC/ clusters is to assume that native speakers are aware of the phonotactic regularities of their own language and can even build safe inferences based on them. Now, while this is generally more than plausible, as Treiman (1988) and Brent & Cartwright (1996) demonstrate, the logical consequences appear to be vacuous with respect to the syllabification problem discussed in this paper. A little Gedankenexperiment demonstrates this. Suppose that tautosyllabicity replaced, at some point, the formerly heterosyllabic treatment of /sC/ clusters, so that the syllabification of *testa* changed from /tEs.ta/ to /tE.sta/. What would this entail? The discomforting answer

is that no compelling conclusion follows. In the absence of the triggering mechanism (i.e., the diphthongization process), the form */tjE.sta/ cannot possibly emerge, and this suffices to explain the lack of words violating the distributional regularity in question. This makes the argument completely void, leading to the conclusion that the phonotactics of diphthongization does not discriminate between alternative syllabification outputs. For more clarity, the different phases may be reconstructed as follows. In the first stage, Italian stressed /E O/ diphthongized in open syllables, and crucially never did before /sC/ clusters. In the second stage, diphthongization died away as a synchronic process, so that stressed /E O/ no longer obligatorily diphthongized in open syllables. Despite this, there is no compelling reason to imagine that /sC/ clusters were no longer treated as heterosyllabic. In the third and final stage, however, one may legitimately suppose that the heterosyllabicity of /sC/ clusters ceased to operate, without producing any observable consequence. Should this be the case, the Italian lexicon would look exactly as it presently does, although admittedly, and quite disturbingly, its appearance is equally compatible with the heterosyllabic treatment of /sC/ clusters.

In addition to the above considerations, further arguments may stem from modern loan-words and neologisms involving /sC/ clusters, showing that Contemporary Italian does not any longer comply to the heterosyllabic inclination that was present in Ancient Italian. Bertinetto (1999) discusses several examples of this sort, concluding that the syllabification of /sC/ clusters in present-day Italian is likely undecidable.[5] The phonology of the language is in most cases compatible with both types of syllabification, and sometimes even provides some evidence for the tautosyllabic solution.

This paper addresses the issue from the experimental perspective. It should be regarded as the empirical companion to the previous, more theoretically oriented work. For this reason, this paper will not discuss issues relating to theoretical phonology. Various scholars have proposed an array of solutions for the problem at hand, often exploiting the possibility of multilevel analysis. Depending on the author and on the specific theoretical assumptions, the /s/ of initial /sC/ clusters has been regarded as extrasyllabic, as extrametrical, as the dangling coda of a degenerate syllable, and so forth. Whatever solution one would like to propose for their formal treatment, one should not dismiss the issue of how the native speakers of a given language concretely, i.e. observably, deal with /sC/ clusters, both initial and internal. With this in mind, the following sections will present the results of a number of psycholinguistic investigations con-

ducted in recent years with Italian speakers.

Before beginning, a qualification is in order. This paper does not presume to offer a solution to the formal puzzle, since this is logically impossible. Some phonological theories seem to be completely immovable by empirical evidence. For instance, one may devise a theory in which initial /sC/ clusters appear at a different level than the one where syllabification occurs, so that they do not constitute an organic syllable onset. As for internal /sC/ clusters, one may conceive of a mechanism that enables one to consider them tautosyllabic on one level of analysis, and heterosyllabic on another. Alternatively, one may consider them to be ambisyllabic. In all such cases, except perhaps the last one, no empirical evidence stemming from the speakers' actual behavior would shed light on the formal representation of these clusters. One may easily contend that syllabification occurs at a deeper level than can be currently detected using experiments. This does not mean, however, that this paper has no theoretical ambitions. The discussion will specifically focus on the underlying assumption, present (or implicit) in most approaches to syllabification, that all segments should be unambiguously syllabified. This is the point that section 3 will criticize, for its inability to cope with the experimental evidence presented in section 2.

## *2. Experimental evidence*

### *2.1. A preferred division experiment*

Bertinetto (1977) reports a preferred division task submitted to three groups of participants: EL (eight/nine-year-olds), ME (eleven/twelve-year-olds), UN (university students). The materials included a list of words containing /sC/ clusters, plus a few others containing /tl/ and /tm/ clusters for control. The instructions insisted on the fact that syllabic division should reflect personal intuitions, rather than orthographic conventions. This section will briefly summarize the results. (Here and in the following sections, the experimental data will be limited to the minimum necessary; for further details, the reader should consult the original publications.)

The three groups showed different behaviors. EL, and to an even larger extent ME, followed orthographic conventions by and large, intimating the tautosyllabic division of /sC/ clusters,[6] while UN provided a fairly inconclusive result on the whole. According to $\chi^2$ analysis, most of the test words yielded statistically non-significant results,

and were in fact close to random distribution.[7] By contrast, words containing /tl/ and /tm/ clusters showed the opposite situation, with EL and ME producing undecidable results, and UN separating them as predicted, respectively treating /tl/ vs. /tm/ clusters as tautosyllabic vs. heterosyllabic (e.g., *atleta* 'athlete' /a.tlEta/ vs. *atmosfera* 'athmosphere' /at.mosfEra/).

This seems to indicate the following conclusions. First, orthographic conditioning presumably did not affect the behavior of UN participants, whose responses may be considered as expressions of genuine phonological intuitions. By contrast, conformation to orthographic rules is fairly comprehensible in the younger participants (EL and ME), who may have suspected the experiment was trying to test their knowledge of orthography. The fact that they were unsure of how to handle the rare clusters /tl/ and /tm/, which they were probably never taught in detail, seems to confirm this interpretation. Second, the random response distribution that UN participants yielded with /sC/ clusters, as compared with the sharp results of /tl/ and /tm/ clusters, suggests that /sC/ clusters confront speakers with an undecidable situation, for which their phonological competence (as opposed to the orthographic one) provides no clear orientation.

This experiment, however, does contain some problems. The main flaw is that participants were aware of the experimental aim, which may have awakened their metalinguistic knowledge. As such, three irreconcilable conclusions might be drawn from the above data concerning /sC/ clusters:

- UN participants did actually show undecidable behavior;
- The random distribution of UN responses was possibly due to the participants' attenuation of their supposedly natural (according to the received view) inclination towards heterosyllabic division, as a consequence of orthographic conditioning, exerting a covert influence on their behavior;[8]
- The random distribution of UN responses was possibly due to the participants' desire to exaggerate their heterosyllabic responses in order to gratify the alleged experimenter's expectations (assuming that there is no reason to inquire into a conventionally regulated phenomenon, unless one has an alternative in mind).

Consequently, no clear conclusion may be drawn from this experiment alone (but see below section 2.4 for further elaboration).

*2.2. A language game experiment*

Bertinetto (1987) exploits a language game to investigate Italian's syllabification tendencies. The game consisted of inserting the sequence /gV'sV/ in the appropriate place, where /V/ copies the preceding vowel. The following illustrates the game:

*mano* → MAga'sa - NOgo'so
*lunatico* → LUgu'su - NAga'sa - TIghi'si - KOgo'so.

The experimental goal was to identify the preferred insertion point with respect to various vowel and consonant sequences. The participants had to select the appropriate solution among those accompanying a visually presented list of test words, possibly proposing their own alternative.[9]

This paper only reports the results relevant to the problem at hand. Among the two consonant clusters exhibited below, the sonorant+obstruent type is clearly heterosyllabic in Italian (comforming to the general tendency), whereas the /sC/ type is the target of the present paper. The abbreviations 'T' and 'H' indicate the tautosyllabic and heterosyllabic solutions, while 'A' indicates the 'ambisyllabic' solution occasionally and spontaneously suggested by the participants (the sign ´ indicates the stressed vowel):

*campo* = sonorant+obstruent
T: CAgasáM - POgosó
H: CAMgasá - POgosó
A: CAMgasáM - POgosó
*pasto* = /sC/ clusters
T: PAgasá - STOgosó
H: PASgasá - TOgosó
A: PASgasáS - TOgosó.

The prediction for the sonorant+obstruent type was that there should be a sharp preference for 'H' responses, while no prediction was anticipated for /sC/ clusters.

Before reporting the results, a few clarifications are in order. First, the 'tautosyllabic' solution relating to words such as *campo*, containing a sonorant+obstruent cluster, is tautosyllabic only to the extent that the sonorant is separated from the preceding nucleus. As the example shows, there is no reason to suppose that the sonorant was actually included into the same syllable as the following obstruent. Second, the label 'ambisyllabic' is used fairly metaphorically in

this context, as one can see from the examples. It simply hints at the repetition of the consonant cluster's last element in conjunction with the following syllable's first element. It should thus not be taken in its technical sense. Besides, since there is no structural justification for the ambisyllabicity of Italian non-geminate consonants (as contrasted to geminate ones), one must assume that the participants who suggested this solution somehow opted, so to say, for a sort of emphatic heterosyllabicity. One piece of data clearly licenses this interpretation: namely, the 'A' response appeared even with monosyllables such as *tram* (cf. TRAMgasáM), where the lack of a following syllable depletes the very essence of ambisyllabicity. Consequently, the experimenter decided to pool 'H' and 'A' responses together as examples of the same structural tendency in syllabification.

Taking this proviso into consideration, the predictions were proven correct. The $\chi^2$ test proved that the sum of 'H' and 'A' responses yielded a fairly robust significance with sonorant+obstruent clusters (in fact, 'H' responses alone approached significance), while 'T' responses obtained very low scores. By contrast, 'T' responses reached significance with /sC/ clusters.

The interpretation of these data is less problematic than of the ones reported in section 2.1. Obviously, one cannot rule out the possibility that orthographic conventions partly constrained the behavior of the participants, suggesting a tautosyllabic division of /sC/ clusters. In this case, however, orthography's influence was most likely less dramatic for the following two reasons: (a) The solutions that the experimenter proposed for the language game's implementation (and even more those that the participants added) are fairly remote from procedures of word segmentation in written texts; (b) The difficulties of applying the game to words with some complex consonant and vowel sequences show that the participants were challenged by the inherent problem of inventing a specific strategy.[10] Had they relied on orthographic knowledge, there would have always been a clear advantage for one response over the others.

Summing up, in this experiment /sC/ clusters shared, with very marginal deviations, the behavior of words containing open syllables. It would be rather far-fetched, however, to claim that these data provide evidence for a truly tautosyllabic treatment of these clusters. A more parsimonious conclusion would be simply to suggest that /sC/ clusters behaved quite differently from clearly heterosyllabic clusters, such as sonorant+obstruent clusters. The sharp contrast between these two types is the ultimate lesson to be gleaned from this case,

whatever it may mean.

*2.3. A concept formation experiment*

Bertinetto (1988; 1992) reports the results of a concept formation experiment, in which a group of Italian participants were induced to build a personal strategy for separating two classes of auditorily presented words, without explicit instructions as to their respective structure. The structure of the two classes was as follows (C, V and L stand for 'consonant', 'vowel' and 'liquid'; *x* and *y* indicate that the consonant clusters did not contain geminates):

| | | | | |
|---|---|---|---|---|
| YES: | (i) | (CC)VCV(C) | (ii) | (CC)VCLV(C) |
| NO: | (iii) | (CC)VC$_x$C$_y$V(C) | (iv) | (CC)VC$_x$C$_y$LV(C). |

YES words were characterized by an open first syllable, whereas NO words were carefully chosen so as to exhibit a closed first syllable. Needless to say, no hint at this was provided to the participants. In order to make things less mechanically obvious to them, the onset of the first syllable contained between zero and two consonants, while the second syllable contained an optional coda. As such, participants could not build a strategy merely based on counting the number of phonemes in the word, something that could have easily occurred if the two classes simply consisted of CVCV vs. CVC$_x$C$_y$V words.

An equal number of words of each type were used in the training session, during which the participants had to form the relevant concepts. The only instruction given was to assign each word to the YES or the NO category, following personal intuitions. Of the 40 participants who underwent the training session, only 20 achieved the preset criterion, imposing at least twelve running correct responses, with no more than two misses interspersed. Successful participants were immediately admitted to the test session, which presented them with a number of target words. In addition, there were 16 recalls exhibiting the same structure as the training items, to check whether the participants had retained the just-formed concept. The target words included, among other items, 4 words containing an /sC/ cluster and 6 words containing geminate clusters. The latter items were meant to provide comparison with a typically heterosyllabic sequence.[11]

As it happened, 7 participants were discarded after the test session, either because of inconsistency (if they responded incorrectly to more than 6, out of the 16 recall words), or because they had developed very explicit orthographic criteria for syllabification (as discov-

ered in the final interview). The decision to exclude this latter group of participants was motivated by the need to be as conservative as possible with data interpretation. The 13 remaining participants yielded the following results (once more, only data relevant to the present topic are provided): (a) They were more than 90% consistent with YES and NO recalls; (b) They evenly divided geminate cluster words into 50% for each of the two response categories; (c) As for /sC/ items, they yielded a NO response 68.75% of the time. Apparently, /sC/ items were tendentially assimilated to closed syllable words, rather than to open syllable ones.

One may conclude that this experiment's results contradict those of the previous ones; however, one should be cautious. The participant interviews, at the end of the experimental session, showed that most of them best expressed the opposition between the YES and NO categories using terms such as 'linear, united, fluent, relaxed, more simple' vs. 'distinct, interrupted, tense, less simple'. It thus appears that most participants did not identify the contrast in syllable structure as the kernel of the YES / NO opposition, but based their judgments on an idea of 'fluidity'. This might explain the discrepancy between geminates and the NO words, even though in all other psycholinguistic experiments performed by the present author using Italian participants geminates invariably tended to behave like prototypically heterosyllabic clusters. Given the kind of concept supposedly developed by the participants, geminates were unsurprisingly bound to be the most vulnerable category, for they may easily be characterized in terms of 'fluidity of transition', especially in comparison with /sC/ clusters, which clearly exhibit a sharp sonority contrast.

In conclusion, it is safe to say that this experiment's findings were not easily interpretable.

### *2.4. Repetition and substitution experiments*

Bertinetto et al. (1995) report two experiments addressing the degree of intersegmental cohesion found in the main vowel sequences and consonant clusters of Italian. These experiments may provide indirect evidence for syllabification tendencies.

Each experiment consisted of four different tasks. Experiment-I included four tasks involving disyllabic stimuli: repetition of the first (1) or second syllable (2), substitution of the first (3) or second syllable (4) with the sequence /vu/. The four tasks of experiment-II (5-8) were all based on the first syllable's substitution by means of the sequence /vu/, just as in task 3. The latter substitutions were per-

formed on a series of identical test disyllables, embedded in four different word types, varying according to stress placement or the target cluster's distance from the beginning of the test item.[12] In both experiments, the auditorily presented items were all nonsense words, both before and after the transformation.

Experiment-I's training session included the following materials: (C)'CV(N)CV(C) (with N standing for 'nasal'). There was specific training for each task. The instructions given to the participants did not mention the notion 'syllable'; participants were simply provided with the (orally presented) intended solution, which was straightforward for any training item. For instance, a training stimulus like *prome* would become *proprome* in task 1, *promeme* in task 2, *vume* in task 3 and *provu* in task 4. The variety of structures used in the training session, as for the initial and final part of the item, prevented the participants from devising a mechanical strategy, based on repeating or replacing an identical number of phonemes when appropriate. Furthermore, the presence of /NC/ clusters provided examples of closed syllables.

The test materials included a number of items containing vowel sequences ($CV_xV_zCV$) or consonant clusters ($CVC_xC_{x/z}V$, with geminates as one of the possible cluster types). A few recalls were interspersed to reinforce the learned strategy. This paper only reports data concerning the following three cluster types: (i) obstruent+liquid (OL, where O does not include /s/), known to be tautosyllabic in Italian, as in most languages; (ii) liquid+obstruent (LO), known to be heterosyllabic; and (iii) /sC/, which is the target of the present paper. Of particular interest is the relative position of /sC/ clusters with respect to the other two.

The orally produced responses were classified as type A or type B, depending on whether the two members of the source cluster were kept together (A) or separated (B). For instance, the item *lerpo*, containing the cluster /rp/, could have provoked the following responses: *lelerpo* (A) or *lerlerpo* (B) in task 1, *lerporpo* (A) or *lerpopo* (B) in task 2, *vurpo* (A) or *vupo* (B) in task 3; *levu* (A) or *lervu* (B) in task 4. The prediction was that different clusters would yield different distributions for the two types of response.[13]

Table 1 displays the relevant figures, presenting the percentages of the various response types. As can be seen, /sC/ items occupy an intermediate position with respect to OL and LO items in every task. Pairwise *t-test* comparisons showed that the OL set was significantly different from the other two. Further comparisons performed on single tasks revealed that /sC/ and LO significantly differed in task 4.

The results of experiment-I thus suggest that OL items stand alone, while /sC/ items statistically differed from LO items in just one task out of four, even though the actual figures of these two sets are always different from each other.

Experiment-II (tasks 5-8), whose results appear in table 2, provided additional information. Although the procedure was essentially the same, there was one major difference in the training materials: in order to include the sequence nasal+obstruent in the test materials,

**Table 1.** Experiment-I (tasks 1-4): Intervocalic clusters. Types of response (percent results): A = cluster preservation; B = cluster splitting; X = errors and misses.

| | task 1 | | | task 2 | | | task 3 | | | task 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| type of cluster ↓ | *A* | *B* | *X* | *A* | *B* | *X* | *A* | *B* | *X* | *A* | *B* | *X* |
| *OL* | 99.1 | 0 | 0.8 | 93.3 | 1.2 | 5.4 | 98.3 | 0 | 1.6 | 97 | 0 | 2.9 |
| */sC/* | 70 | 26.6 | 3.3 | 41.2 | 58.3 | 0.4 | 77.9 | 21.2 | 0.8 | 23.3 | 76.2 | 0.4 |
| *LO* | 59.6 | 39.5 | 0.8 | 15 | 83.7 | 1.2 | 73,3 | 22.5 | 4.1 | 9.5 | 90 | 0.4 |

the training items presented no internal consonant cluster whatsoever. Of the two features that factorially varied in tasks 5-8, namely stress placement and distance from the test word's beginning, only the former turned out to be significant. Accordingly, there is no reason to report separately the data of tasks 5 and 7 against tasks 6 and 8 (see fn. 12). The pairwise *t-test* comparisons, based on percentages, showed that all previously considered clusters (OL, LO and /sC/) differed significantly with respect to one another in the whole data set. The difference between OL and /sC/ was however non-significant in tasks 6 and 8, namely when the target clusters were located before the stressed syllable. Table 2 also exhibits the data for the nasal+obstruent category (NO), which will be useful for further comparison. As predicted by Italian phonotactics, LO and NO stimuli did not statistically differ from each other, and as a matter of fact produced almost identical results.

**Table 2.** Experiment-II (tasks 5-8): Intervocalic clusters with differing stress position (percentages). See table 1 for the explanation of the symbols used.

| | after stress (tasks 5 and 7) | | | before stress (tasks 6 and 8) | | |
|---|---|---|---|---|---|---|
| type of cluster ↓ | *A* | *B* | *X* | *A* | *B* | *X* |
| *OL* | 95.1 | 1.0 | 3.8 | 91.0 | 6.0 | 2.9 |
| */sC/* | 88.5 | 8.7 | 2.7 | 82.9 | 13.5 | 3.5 |
| *LO* | 68.1 | 27.3 | 4.5 | 63.5 | 32.5 | 3.9 |
| *NO* | 71 | 22.9 | 6 | 59.3 | 35.4 | 4.6 |

Experiment-II's findings somewhat opposed those from the previous experiment as to /sC/ items. They seemed to show more solidarity with OL than with LO items, although they differed altogether from both cluster types. The logical conclusion to be drawn from both experiments is that /sC/ clusters likely represent an intermediate case between clearly tautosyllabic and clearly heterosyllabic clusters.

The fairly indirect nature of the information gathered on Italian's syllabification tendencies increases this conclusion's relevance. The participants performed rather unusual tasks, unrelated to the actual process of syllabification. This circumvents the main objection that could be leveled against the experiment described in section 2.1 above, and in turn lends support to those findings. Since /sC/ clusters generally behaved in a way that can be reconciled with neither tautosyllabic (OL) nor heterosyllabic clusters (LO and NO), the undecidable behavior emerging from the preferred division task in section 2.1 is unlikely a purely artifactual outcome.

### *2.5. Another substitution experiment*

Bertinetto (1998) reports a further word manipulation experiment, consisting of replacing the target nucleus using the sequence /ul/. The auditorily presented items were all meaningless, both before and after the transformation.

The experiment consisted of two tasks, whose stimuli differed with respect to stress location. For the purposes of this paper, it shall suffice to say that each task included the following three classes of test items, respectively containing OL, /sC/ and NO clusters (see section 2.4 for the abbreviations). The target clusters were inserted immediately after the stressed vowel. The two stress profiles were obtained by embedding an identical series of disyllables into a trisyllabic frame,

created by adding CV pseudo-suffixes or pseudo-prefixes. Task 1 items had the shape 'CVCCV*xx*, while task 2 items appeared as *xx*C˙VCCV, where *xx* stands for the pseudo-affix. Hence, the phonotactic environment was the same in both tasks (cf. fn. 12 for a similar solution).

The orally produced responses were recorded and subsequently analysed according to the following classification, where X includes both errors and misses (the sign ´ indicates the stressed vowel):

| Types of response | (example: *físcopa*) | |
|---|---|---|
| A | *fúlSCopa* | = preservation of the full cluster |
| B | *fúlCopa* | = loss of the first consonant |
| C | *fúlSopa* | = loss of the second consonant |
| X | … | = errors and misses |

Table 3 reports the results. The data of the two tasks are lumped together, since statistical analysis revealed that there was no significant difference between the two stress profiles. A series of Wilcoxon tests within both A and B responses were performed on the various cluster types, pairwise compared. All comparisons proved to be highly significant, except the one between /sC/ vs. OL, which was non-significant. These findings indicate that /sC/ clusters behaved like the clearly tautosyllabic clusters OL, and differed remarkably from the heterosyllabic clusters NO. This outcome is much sharper than the outcome stemming from experiment-II reported in 2.4 (the presence of NO clusters in both cases provides a valid term of comparison).

Type C's responses were in general fairly rare; however, they remarkably increased with NO stimuli, suggesting greater difficulty to apply the substitution procedure with heterosyllabic clusters. As for X responses, although they were generally quite rare, they turned out to be especially rare with OL items. This shows that this set most naturally lent itself to the transformation's mechanics.

It is worth remarking that the information concerning syllabification stemming from this experiment is just as indirect as the one stemming from the experiments described in section 2.4. The same

**Table 3.** Percent result of the -UL- substitution test subdivided by cluster type.

| | *A* | *B* | *C* | *X* |
|---|---|---|---|---|
| *OL* | 90.00 | 6.25 | 1.25 | 2.50 |
| */sC/* | 82.50 | 9.68 | 0.93 | 6.87 |
| *NO* | 25.93 | 63.43 | 4.06 | 6.56 |

observations made above, concerning the findings' reliability, also apply in this case.

*2.6. Duration measurements of V - C ratios*

Italian is described, at least since Josselyn (1900), as characterized by a syllable-weight-conditioned vowel-duration process affecting stressed syllables. For instance, the stressed /a/ of *fato* 'fate', located in an open syllable, is longer than that of *fatto* 'made', located in a closed syllable. Although this regularity is generally presented as a fact, it is actualized only under intonational phrase stress, crucially including isolated words. By contrast, it tends to vanish in connected speech, even of the laboratory type, as claimed in Bertinetto (1981). To the extent, however, that this regularity is observed in the relevant situations, it provides a valuable diagnostics for evaluating syllable boundaries. It may thus be worthwhile to examine the findings of acoustical measurements comparing vowel durations in open syllables with vowel durations before /sC/ clusters, as well as before clearly heterosyllabic ones, including geminate clusters.

Ferrero (1972) indicates that the stressed vowel before /sC/ clusters is systematically longer than before geminate clusters. In contrast, Fava & Magno Caldognetto (1976) show that their Central Italian speaker tended to shorten stressed vowels before /sC/ clusters. Vogel (1982:50-52) reports the data of three speakers (one from Florence, two from the province of Rome). Of these, one shortened the stressed vowel in /sC/ contexts, one did not, and the third adopted an intermediate strategy. Farnetani & Kori (1986) repeated the measurements with two Northern Italian and one Central Italian speaker. They found that they all tended to shorten stressed vowels before /sC/ clusters. Interestingly, however, their Central Italian speaker did not lengthen the /s/ at the beginning of an /sC/ cluster as compared to the same consonant in intervocalic position, thus deviating from the usual behavior of coda consonants.

This is confirmed by Korzen (1981:175-8), who examined the duration of a number of consonants in intervocalic position and in different clusters among 6 speakers from Florence and the surrounding area. The relevant piece of data is the following. In general, the duration of sonorant consonants in coda position tended to be longer than when in the intervocalic position: 61 vs. 46 ms for /m/, 75 vs. 44 ms for /n/, 84 vs. 46 ms for /l/.[14] By contrast, the durations of /s/ in /sC/ clusters and in the intervocalic position were 63 vs. 86 ms, suggesting that the syllabic behavior of /s/ diverged from that of the typical coda consonants.

Marotta (1995a) presents more extensive measurements for /VsC/ sequences. She studied the behavior of two Central and four Southern speakers, reading disyllables and trisyllables both in isolation and in carrier sentences. Since the target vowels in her trisyllables were unstressed, the most relevant data refer to disyllables, where stressed vowels tended to shorten before /sC/ clusters in isolated words. In carrier sentences, however, this tendency was much less evident, and with two Southern speakers (those with the fastest rate) it was altogether lacking.

Turchi & Bertinetto (2000) recently provided further relevant data, based on the analysis of 20 speakers from Pisa (Central Italy). Although the majority of them tended to shorten the stressed vowel before /sC/ clusters, with some speakers this tendency was absent or negligible. Since this is the only study based on a relatively large group of speakers, the variability observed in the results sheds some light on the somewhat puzzling variability emerging from the above works. Apparently, different speakers follow different strategies. This is a highly relevant point, which will receive further discussion in the conclusion.

Summing up, /sC/ clusters generally tended to shorten the duration of preceding stressed vowels in careful pronunciation, according to the behavior of clearly heterosyllabic clusters. This does not however occur among all speakers, and it unlikely depends on geographical origin, since the Central Italian speakers studied by Magno-Caldognetto & Fava**,** Farnetani & Kori, and Turchi & Bertinetto show diverging inclinations. This sort of variability appears even among speakers of the same community, and this author would not be surprised if future research revealed variation within a single speaker's production. In addition to the stressed vowel's variable duration, some of the reported data suggest that the duration of /s/ in /sC/ clusters does not conform, at least for some speakers, to the typical behavior of coda consonants. This also casts doubt on the alleged heterosyllabicity of such clusters.

### *2.7. Other languages*

This section will briefly consider the experimental evidence referring to languages other than Italian, namely English, German and Finnish.

Treiman, Gross & Cwikiel-Glavin (1992) conducted three experiments using American participants. Their material consisted of nonsense disyllables including /s/+stop, /s/+sonorant, and obstruent+liq-

uid word-internal clusters. The three experiments involved: (i) a preferred division task, similar to the one reported in section 2.1; (ii) an oral syllabification task, in which participants were asked to divide the test stimuli into syllabic chunks; (iii) a pronunciation task concerning non-word stimuli, where the dependent variable was the degree of reduction of the unstressed vowel preceding the target cluster. Minor details aside, the findings confirmed that the syllabification of English /sC/ clusters is definitely heterosyllabic.[15]

Berg & Niemi (2000) conducted a comparative study with German and Finnish participants. The disyllabic stimuli used, which were exactly the same for both groups of participants, were phonotactically legal non-words in both languages. They exemplified a number of di- and triconsonantal internal clusters, including those of interest for the present paper (/sC/ and sonorant+/st/ clusters). The two tasks involved: (i) syllable inversion and (ii) repetition of the first syllable, as in the relevant tasks of the experiments described in section 2.4. Finnish speakers prevalently treated /sC/ clusters heterosyllabically, whereas German speakers treated them tautosyllabically.[16] This contrast seems to accomodate nicely a macroscopic phonotactic difference, namely that German allows for /sC/ clusters to appear word-initially, whereas Finnish forbids all sorts of diconsonantal onsets in the autoctonous lexicon. This can not be the whole story, however, for English also presents /sC/ clusters word-initially, yet their word-internal syllabification is clearly heterosyllabic.[17]

## *3. General discussion*

The data discussed in section 2 provide sufficient information to advance a tentative conclusion. Although the experimental data concerning languages other than Italian are scanty, section 2.7 shows that German may be another possible candidate for a language where /sC/ clusters behave differently from typically heterosyllabic ones. As such, Italian should not be regarded as an absolute exception.

As far as the latter language is concerned, the situation appears to be as follows. Measurement experiments (section 2.6) seem to indicate some preference for the heterosyllabic behavior of the clusters under analysis. At the same time, they leave open the possibility that this behavior expresses a statistical tendency, rather than an inviolable structural regularity. Different speakers seem to follow different strategies. This is indeed not a new observation. Davis & Hammond

(1995) and Barlow (2001), studying the application of the so-called 'Pig Latin' language game by English speakers, notice that speakers split into two distinct groups, depending on alternative syllabification strategies. This may explain some of the seemingly messy data occasionally gathered in experimental works. It is quite common that not all participants yield exactly the same output in experimental research; however, not every phenomenon reflects the presence of diverging strategies among speakers. In the case at hand, some clusters appeared to be handled fairly unambiguously, while other clusters gave rise to more or less entropic behavior. Whatever the reason for this discrepancy, it must be taken into account. The different syllabification 'grammars' possessed by individual speakers conceivably point to areas of chaotic variation, eventually leading to restructuring in later stages of the language.

With this in mind, one may reconsider the psycholinguistic experiments reported in sections 2.1-5. The findings can be summed up as follows (ignoring the concept formation experiment of section 2.3, whose results were not easy to decipher):

- some data suggest that /sC/ clusters, although occupying an intermediate position between tauto- and heterosyllabic clusters, are closer to the latter (see experiment-I of section 2.4);
- other data suggest that /sC/ clusters, while occupying an intermediate position between tauto- and heterosyllabic clusters, are closer to the former (see experiment-II of section 2.4);
- still other data suggest that /sC/ clusters definitely behave unlike the clearly heterosyllabic sonorant+obstruent clusters (see the language game experiment of section 2.2);
- moreover, still other data suggest that /sC/ clusters behave very similarly to the clearly tautosyllabic obstruent+liquid clusters (see the substitution experiment of section 2.5);
- finally, the preferred division experiment (see section 2.1) suggests that the syllabification of /sC/ clusters is likely to be undecidable.

The preceding summary shows that the various tasks produced contrasting results. This may be disconcerting for formal phonologists, but it is certainly not for experimentally minded ones, who consider their findings as a function not only of the particular choice of linguistic materials and of the hidden structural properties of the examined language, but of the particular technique employed. As Derwing (1997) claims, experimental results may be considered

robust only when the findings of different experimental tasks converge. The aim is now to determine whether the results reported above converge towards a precisely identifiable outcome. This author's interpretation is that they do.

First, with the exception of the preferred division experiment, all tasks involved behavioral operations which did not directly call explicit syllabification procedures into play. This ensures that the participants' behaviors were not influenced by metalinguistic knowledge. Second, the varying results obtained for the /sC/ clusters in different experiments is likely a reflection of the case-by-case different interplay of linguistic materials and experimental techniques, and of the attrition of both with the hidden prosodic properties of the examined language. In any case, although the participants' reactions differed, following the impetus of the particular experimental task exploited, it crucially appears that /sC/ clusters should not be confused with the typically tautosyllabic clusters, nor with the typically heterosyllabic ones. Third and most important, the findings reported in section 2, taken altogether, strongly suggest the undecidable nature of the /sC/ clusters' syllabification, precisely because they do not yield the same results consistently yielded by either the tautosyllabic or the heterosyllabic clusters. This coordinates with Bertinetto's (1999) theoretical analysis, and in turn lends support for the preferred division experiment's outcome, as described in section 2.1: the undecidable syllabification strategy observed among the older UN participants ultimately seems to correspond to a real piece of data.

This outcome should not be considered embarassing. As Vennemann (1994) claims, linguistic theory should not demand that every consonantal sequence be uniquely, i.e. unambiguously syllabified. Hence, syllabification should not be regarded as an invariably deterministic process, but rather as a process allowing for probabilistic behaviors in at least some problematic and somewhat marginal areas. It is no wonder that /sC/ clusters constitute a problematic case, given that they often violate the 'sonority principle', to which natural language syllables normally adhere.[18] The /rt/ cluster in Polish is another possible phenomenon of this sort,[19] and many more examples likely exist in other languages among infrequent clusters, possibly exhibited in a few special words. Even if an elegant formal treatment were devised for these recalcitrant cases, one must still accept that some consonant clusters, as studied experimentally, tend towards undecidability. On top of that, one must also accept that a cluster that appears to be perfectly decidable in one language may appear undecidable in another.

This view has the merit of reconciling linguistics with the mainstream of scientific research in the natural sciences, which has insisted on the probabilistic nature of many observable phenomena, at least since Prigogine's inspiring work. This is not to deny that there are clearly definable examples of perfectly deterministic behavior obeying well-behaved physical 'laws'. As is the case in the natural sciences, not just any linguistic phenomenon undergoes the capricious effects of probabilistic behaviors. This paper's claim should thus not be interpreted as an advocation for the replacement of linguistics' traditional theoretical views with a thoroughly probabilistic conception inspired, for instance, by connectionist approaches. Rather, the claim, very much in line with the rethinking of the notion 'rule' in recent linguistic theorizing, is to reconsider the situation at all levels of linguistic structure, separating the plausibly regular behaviors from those that are best accounted for by a probabilistic, more performance-oriented perspective (cf. Bertinetto 2003 for the spell out of this view).

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*Notes*

[1] As an example of the 'heterosyllabic' vs. 'tautosyllabic' division of /sC/ clusters, one may consider It. *pasta* 'noodles': /pas.ta/ vs. /pa.sta/.
De Weijer deals more specifically with /s/+stop clusters, which often behave differently from /s/+sonorant clusters. In the word-initial position, the former clusters provide a striking violation of the 'sonority principle', that intimates rising sonority contours in onsets as opposed to falling sonority contours in codas. /s/+sonorant clusters, in contrast, do not constitute a problem for syllable theory, for sonorants are (by name) more sonorous than fricatives. /s/ is thus perfectly eligible to serve as the initial element in such complex onsets. Considering, however, that in Italian there are no major distributional differences between these two types of cluster, one may disregard this difference.

[2] Davidsen-Nielsen (1974) claims that English presents tautosyllabic division in /sC/ clusters. Although there are an overwhelming number of arguments in favor of the alternative solution, the position defended by Davidsen-Nielsen is worth noting. It shows that languages may convey contradictory indications even in seemingly straightforward cases.

[3] The only remnant of this seems to be the stereotyped idiom *per iscritto* 'in written form', which belongs to the bureaucratic language. The tendency towards postlexical epenthesis only survives in some local varieties, such as Florentine (which, despite similarities, should not be identified with Standard Italian).

The sporadic attestations of vowel prosthesis before /sC/ in Late Latin inscriptions shows that this process must have arisen before the birth of Romance languages, which explains its widespread presence in the Romance domain (Lupino 1999).

[4] In some cases, the Florentine dialect did lose these diphthongs, and some of the resultant words actually enjoyed a period of popularity in traditional poetry (e.g., one may find *foco*, instead of *fuoco*, in poetic language). Most words, however, retained their diphthongs, while analogical leveling in verb declension created many more.

[5] The word 'undecidable' might cause confusion. One might misinterpret it in the sense that the issue would be decidable, if only linguists were smart enough to come across the right pieces of evidence. In this paper, however, this term should be understood in a stronger sense, namely that the syllabification of /sC/ clusters is undecidable even by native speakers themselves.

[6] This is worth noting, for it seems to indicate that the grammarians who dictated this rule where somewhat aware of the peculiar nature of these clusters. Nonetheless, one should not attach decisive relevance to this detail. See, in this connection, Derwing's (1992) discussion of Korean orthography.

[7] There are a few deviations from this tendency, which are open to interpretion. For instance, some UN participants occasionally preferred the tautosyllabic solution, presumably to preserve the boundary between prefix and root (/anti.spastiko/, /pre.skrivere/, /diz.dZundZere/). This was not always the case though, as in /tra.zduttore/, /tra.zgredire/, /di.zgregare/, /tra.zlare/. Interestingly, in the latter cases the /s/-final prefix precedes a bounded root, which may have obscured the morpheme boundary.
Another conditioning factor was the presence of an internal word boundary (cf. /artErio+sklerOtiko/). A further, very powerful factor was the presence of triconsonantal clusters, which invariably, and indeed predictably, favored the tautosyllabic solution (/per.spikuo/, /per.spikatSe/).

[8] The role of orthography should not be underestimated. In a fundamental paper, Derwing (1992) has convincingly shown that orthography may occasionally condition a speaker's phonological competence. Obviously, each case must be individually examined.

[9] Some participants spontaneously suggested a sort of 'ambisyllabic' solution (in a sense to be clarified below), which was unforeseen by the experimenter.

[10] Part of the remaining experimental data are provided below:
- monosyllables, diphthongs and complex clusters (like: /nsfr/ in *transfrastico*, /stm/ in *istmo*) show that participants found it quite difficult to devise a consistent strategy;
- /tl/ clusters yielded a clear advantage for 'T' responses, while with /tm/ clusters the sum of 'H' and 'A' responses approached significance.

[11] The heterosyllabic syllabification of geminate sequences conforms to the traditional, indeed generally agreed upon view. Only a tiny minority of phonologists proposed the alternative interpretation, crucially assuming structural indivisibility of long consonants.

[12] The following shows the structure of experiment-II's test materials:

| | | | |
|---|---|---|---|
| task 5: | 'CVCCV*xx* | task 6: | CVC'CV*xx* |
| task 7: | *xx*'CVCCV | task 8: | *xx*CVC'CV |

The sequence *xx* stands for a CV pseudo-suffix or pseudo-prefix. The set of test disyllables embedded in each word type was the same in all four tasks, to preserve identical local phonotactics.

[13] Apart from responses A and B, participants occasionally produced responses that were considered as errors. These are indicated by X in tables 1 and 2. The

percentage of errors and misses in the subset of data under consideration, depending on the task and cluster, ranged between 0.4% and 6%.

[14] The coda position is typically occupied, in Italian, by sonorant consonants (namely /m n l r/), to the exclusion of palatal sonorants (/ ¥/. Most phonologists attribute this property to /s/ as well (cf. Baroni 1993 and Marotta 1995b for some recent proposals); the purpose of this paper is to provide a more nuanced view.
The durational data reported in the text do not include /r/, since its duration is fairly short in the positions of interest to this discussion.

[15] The conclusions of Stemberger & Treiman (1986) are less straightforward. These authors studied English consonantal clusters in spontaneous and experimentally induced speech errors. Depending on the type of error, /sC/ clusters resembled or diverged from obstruent+liquid clusters. The appropriate interpretation of these data, however, is not always obvious. For instance, the authors consider *What's the BRest Band?* (for *What's the Best BRand?*) as an example of C2 addition, yielding a cluster in the first word; yet there are several other possible interpretations, such as the one in which the complete onsets of the two words exchange their positions, preserving their own integrity.

[16] As for sonorant+/st/ clusters, the sequence /st/ appears to be treated heterosyllabically in both languages, although not overwhelmingly so.

[17] In German, as opposed to English, the fricative in /st/ and /sp/ sequences is palatalized to [St] and [Sp], suggesting strong coarticulation in these cases (assuming that [S] requires less gestural precision than [s]). This observation, however, does not add compelling evidence. Italian (except for some substandard varieties, like the one spoken in Naples) is like English in this respect, for it does not present this sort of palatalization; yet it seems to depart from English in the syllabification of /sC/ clusters.

[18] This assertion is valid to the extent that the 'sonority principle' (see. fn. 1) actually matters for syllabification. As a number of authors would contend, this principle may simply be the observable consequence of deeper regularities, rather than serve as the actual basis for the syllabification processes (Vennemann 1994; Dziubalska-Ko aczuk 1995; Ohala & Kawasaki-Fukumori 1997).
A frequently cited deviation from the 'sonority principle', apart from word-initial /s/+stop clusters, is the differing distributional properties of /tl/ and /dl/ from those of /tr/ and /dr/ clusters. In terms of sonority, all these clusters do not differ significantly; however, /tl/ and /dl/ are much more constrained than /tr/ and /dr/ in most languages, possibly for articulatory reasons. One might contend (as a referee suggested) that the rhotic is more sonorous than the lateral. There is certainly support for this claim; nevertheless, this would not explain why the distribution of /tl/ and /dl/ differs vis-à-vis /tr/ and /dr/ in quite a number of languages, while nothing of the sort happens for /pl/, /kl/, /bl/ etc. vis-à-vis /pr/, /kr/, /br/ etc.

[19] The present author, in collaboration with Katarzyna Dziubalska-Ko aczyk and Silwia Schever from Poznan, is currently conducing an experiment investigating Polish clusters.

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