The Syllable: Fragments of a Puzzle

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1. *The syllable puzzle.*

Few linguistic concepts are at the same time so intuitively clear and so hopelessly elusive as that of the syllable. The density of research on this notion has grown relentlessly in the last two decades, but apparently this seems to have increased, rather than reduced, the fog surrounding it. Given this state of affairs, presuming to solve once and forever the syllable's puzzle would definitely appear to be too daring a goal. My purpose here is simply to attempt to assemble a few pieces of this growing puzzle, in the hope of putting some (provisional) order into one part of this complex picture.

1.1. *Starting the game.*

The pieces with which my game starts concern the behaviour of Italian subjects in psycholinguistic experiments. As summarized in Bertinetto (to appear/a), in segment(s) substitution tasks Italian subjects do not show any strong syllabic effect.[1] This contrasts with the behaviour of English subjects, who consistently provided evidence of a robust structural hierarchy within the syllable.[2] Indeed, as repeatedly demonstrated by Rebecca Treiman and Bruce Derwing's teams (Treiman 1983, 1986; Derwing et al. 1988; cf. Bertinetto, to appear/a, for more references), English presents a sharp inclination towards Right-Branching internal geometry (henceforth **R-B**), where the Rhyme node dominates Nucleus and Coda, while the Onset remains undominated. However, when Italian subjects were asked to perform time-compressed blending tasks, the syllabic effect emerged very neatly. That this is not purely coincidental, possibly due to undiagnosed failures of experimental procedure, is shown by the behaviour of Spanish subjects, who show essentially the same reactions as the Italian ones (Bertinetto et al. 1999).

In the same way, it has been shown (Bertinetto, to appear/b) that Italian spontaneous blendings - 'blending errors' - are overwhelmingly produced by joining an Onset of the first source-word with a Rhyme of the second: a perfect R-B structure. A much weaker R-B orientation emerges, on the other hand, in Italian 'lexical blendings', i.e., willful creations like *polstrada* (*pol*<lizia (della)+>*strada*), whereas English lexical blendings, like *brunch* (*br*<eakfast +l>*unch*), appear to obey to a much larger extent the 'On+Rh' recombination.

Thus, even though we may claim that - despite conflicting evidence - the deep inclination of the Italian syllable leans (if anything) towards R-B, the problem remains. What is the reason why Italian, as opposed to English, presents such a weak R-B orientation? Or, to put it differently, why is the internal geometry of the syllable in Italian is so unstable as to be influenced by

the type of phenomena to be scrutinized (segment(s) substitution vs. blending tasks, lexical blends vs. blending errors)?

1.2. *Early vs. late prosodic build-up?*

One possibility, certainly worth exploring, is the one put forth by Berg & Abd-el-Jawad (1996), according to which different languages erect hierarchical prosodic structures with different speeds in the course of language processing. Contrasting the pattern of spontaneous speech errors in an Arabic variety vs. English and German, these authors suggest that the exceptionally high degree of freedom in segment interferences and permutations shown by Arabic is evidence that, at the point where the production system goes astray in this type of error, the syllable hierarchy does not yet play a role in this language, whereas it does in English and German, where an earlier build-up of syllabic structures is to be assumed. This view is certainly not welcome to phonologists who attribute a deep constitutive role to the syllable, but may easily be reconciled with the ideas of those who consider the syllable an epiphenomenal self-organizing structure that emerges at relatively shallow levels of processing as a result of the complex phonotactic interactions operating in the given language (Vennemann 1988; Ohala & Kawasaki- Fukumori 1997; Dressler & Dziubalska Kołaczyk 1994; Dziubalska Kołaczyk 1995).

The fact that the syllable's internal organization is in strict relationship with phonotactics has of course been known for quite a long time, but until recently no cogent statistical procedures were used to measure this phenomenon. Kessler & Treiman (1997), for instance, have demonstrated that in English uninflected CVC words there are significant correlations between Nucleus and Coda - and even between Onset and Coda, in terms of negative correlations - whereas no such associations exist among Onset and Nucleus. Thus, while the transition between Onset and Nucleus is highly informative, the transition between Nucleus and Coda is much more predictable.[3] Of course, the degree of informativity varies from language to language. In Arabic it is certainly higher than in English, while in Italian it is presumably lower. But how can we reconcile Berg & Abd-el-Jawad's suggestion with the available experimental data? Is it the case that the simpler - i.e., the less informative - the phonotactics, the earlier the erection of prosodic structures? This is too simplistic a view. Indeed, the fact that Italian subjects (in contrast with English ones) do not exhibit a clear orientation towards any type of syllabic hierarchy in segment(s) substitution tasks suggests that Italian, despite having a simpler phonotactics, is likely to have a later build-up than English.

One tentative solution could be along the following lines. An exceedingly high degree of phonotactic complexity, as in Arabic, might - for obvious reasons - slow down the syllabic build-up process. But also a relatively simple phonotactics, as in Italian, might yield the same result, on the assumption that early build-up matters only in languages whose degree of phonotactical complexity is comprised within certain limits. Supposedly, when phonotactics

is too simple, the syllable is not particularly helpful as a (de)coding device, and when it is too complex it is not informative.

While this hypothesis has some initial plausibility, the available data are too scanty to prove it. Besides, one should not forget that the output of experimental investigations is heavily conditioned by the specific techniques employed. Thus, no conclusion can be drawn until the cognitive level hit by each of these has been perfectly understood. A preliminary speculation will be attempted in section 2.

1.3. *On the role of the syllable.*

It has been proposed that the function of the syllable correlates with the basic prosodic typology of natural languages. According to this view, advocated in particular by Anne Cutler (e.g., 1997), the syllable plays an important role in word recognition only in syllable-timed languages, whereas it does not in stress-timed ones, where speech segmentation is guided instead by other devices, such as heavy syllables' detection. Evidence for this supposedly comes from the syllable monitoring tasks run by Jacques Mehler and co-workers (Mehler et al. 1981; Cutler et al. 1986), where English subjects did not show any syllabic effect whereas French ones did, as well as Portuguese, Spanish, Catalan and Dutch subjects (Morais et al. 1989; Sebastián-Gallés et al. 1992; Bradley et al. 1993; Zwitserlood et al. 1993).[4,5] On this basis, one is invited to suggest that the latter languages build up syllable structure earlier than English. However, English seems to have a very early syllabic build-up in structure induction tasks (Pitt et al. 1998), as well as in the tasks discussed in section 1.1. Admittedly, the situation looks literally puzzling.

However, despite the appeal of the above proposal, the view inspired by prosodic typology is not compelling. It is certainly compatible with the behaviour of French, Spanish, Catalan and Portuguese subjects in syllable monitoring tasks; but what about Dutch, a stress-timed language? Besides, considering that Italian is syllable-timed, we should expect to find sharp sensitivity to the syllable by Italian subjects, but in fact - at least in segment(s) substitution tasks - their behaviour is relatively insensitive to syllable structure as compared with English ones. Note that this paradox dissolves if the behaviour of the latter subjects in syllable monitoring tasks is understood in its proper terms (see below, especially section 2). But it is also worth pointing out that the interpretation of the contrast stress- vs. syllable-timing as proposed in Bertinetto (1989) - where phonotactically-driven articulatory constraints play a decisive role - suggests a radically different view. According to this view, there are no grounds for attributing a constitutively alternative role to the syllable (conceived of as an abstract phonological unit) in prosodically diverging languages. Phonotactics is all that makes the real difference.

Let us now consider some possible ways-out. The first one consists in restricting the validity of syllable monitoring experiments, which indeed have recently been criticized by Frauenfelder and co-workers, who could not

replicate the original syllabic effect in French (Frauenfelder & Content 1999). They observed instead that their subjects, rather than decomposing the incoming speech signals into syllables, try to locate the most promising syllable-initial components. This is of course another way of using the syllable as support for speech segmentation, but is alternative to Mehlers's approach, where the syllable is regarded as a sort of template against which the speech signal is matched. This is what Frauenfelder & Content call the 'classification' view, as opposed to the pure 'segmentation' view. Does this mean that English subjects, who did not show any syllabic effect in syllable monitoring tasks, do not attach any importance to the syllable even as a segmentation device? This is implausible. Levitt et al. (1991), in a visual-input lexical decision task with intrusion of a non-linguistic sign located in different positions within the word, found that English subjects are more alerted by the border between Nucleus and Coda than by any other intrasyllabic location. The possible reason for this is that, in a language with relatively complex Codas, it is more advantageous for the speaker - for segmentation purposes - to address her/his attention to precisely those portions of the speech signal. Thus, the selective attention that speakers address to different portions of the syllable is possibly modulated by the phonotactic properties of the given language. (Note, however, that this diverging behaviour of French and English subjects has been observed through the use of different experimental techniques.)

The second - and, in my view, more promising - way-out consists in disentangling two roles of the syllable, which correspond to alternative levels of cognitive processing and fulfill different purposes. We know from a number of studies that speakers are often intuitively sensitive to the presence of syllabic units. This has been proved - just to give a hint - in tasks of 'sound similarity judgements' performed with various languages (Derwing & Nearey 1994; Yoon & Derwing 1995), or in tasks of short-term recalling of word lists performed with English subjects (Treiman et al. 1994). As the latter authors suggest, although the syllable may not be relevant as an on-line segmentation unit, it may become important at other stages of processing, supposedly playing a decisive role in remembering speech and in lexical access. Perhaps this position could be rendered somewhat milder by suggesting that syllable-related phonotactic aspects are used by the speakers in the segmentation process at some more or less early or late stage, while the identification of syllabic nuclei is an invariably early process.

Thus, of these two fundamental sides of the syllable (the identification of its nucleus and the erection of its internal structure), only the former seems to be of core relevance. This allows the syllable to remain a basic unit of phonology, at the cost however of having no assigned internal structure at the deepest processing stages. The internal geometry should be viewed as a mere epiphenomenon, emerging under the pressure of both low-level factors (phonotactics) and higher-order ones (word-level prosody, i.e., word length, stress position, etc.). This implies that the level at which we experimentally

observe subsyllabic clustering is definitely shallower than that at which syllabic nuclei manifest their presence in speech recognition. Syllable constituents evolve during processing (just as they do in diachrony) as preferential aggregations, or force-fields, whose strength and stability differs from language to language. They are the mere result of the complex interplay of the overall phonological structure of the language.

Yet another, but in fact complementary, interpretation of the contrasting behaviour to be observed in syllable processing - depending on the experimental task, i.e., ultimately on the processing stage - could be, as has indeed been suggested by several authors, that a given segment may simultaneously be part of more than one syllabic component, although with different weights. This would give rise to a sort of 'variable geometry' structure (something familiar to aeronautical engineers!). This idea has in fact been exploited by Vennemann (1988) in relation to the possible involvement of syllabic components in the diverse syllable-related phonological processes; has been applied by Berg (1989) to the design of a parallel-activation model of the syllable; and has also been adopted by Kessler & Treiman (1997) with respect to the various statistical associations that relate subsyllabic components. By hypothesis, this could also apply to the results of the segment(s) substitution tasks run with Italian and Spanish subjects, where reactions are strongly affected by the shape of the stimulus, i.e., ultimately by features relating to word-level prosody. In this view, the emerging of a certain type of syllable geometry in a given language (namely, Right- or Left-Branching) should not be regarded as equivalent to the fixation of a rigid template; any phonology is a complex organism, admitting many sorts of recombinations. What we should expect to find is therefore not more than a prevailing orientation of syllable-sensitive phonetic regularities and phonological processes along the direction indicated by the dominant internal geometry, without excluding more or less occasional deviations from the main path.

Another problem to consider is whether, in order to produce its effects, the syllable must be conceived of as an object modelled by acoustical factors, or as a more abstract structural unit. The answers to this dilemma vary. Acoustic conditioning has been reported, e.g., in primed syllable-naming tasks (Decoene 1997) and in syllable monitoring experiments (Frauenfelder & Content 1999). On the other hand, Pitt et al. (1998) point out that artificial modification of CV transitions remained ineffective in a structure-induction phoneme monitoring task. However, even though these fine acoustical details may not be perceived by the subjects - possibly because of automatic perceptual restoration - there is little doubt that syllabic structuring could not emerge without the detection of acoustic information in the signal. The real point is, once more, the stage at which acoustical integration, based on allophonic and coarticulatory information, begins.

Ultimately, what definitely appears to be untenable, in light of the knowledge that is accumulating, is any conception of the syllable as a deep abstract

component of phonological organization. All available types of evidence point to the fact that the syllable is gradually built up in the course of on-line language processing; either in the sense that its internal structure becomes gradually perceptible at a given stage (not the same in every language), or even in the sense that different aspects of this entity (nucleus identification vs. erection of internal structure) operate at different levels of processing.

2. ***The experimental puzzle.***

One of the most intriguing tasks of contemporary psycholinguistics is the comparative evaluation of the different experimental techniques. Much of what we are looking for is concealed in their idiosynchrasies. Yet, when properly understood, the latter reveal important aspects of the processing system. Although I am not in the best position to do so, I shall try to advance a few considerations of this matter, in the hope that others will integrate and possibly amend the picture. In the brief review that follows I shall label as **C** (‘core') any result pointing to the relevance (and number) of syllabic nuclei, and as **S** ('structure') those suggesting sensitivity to the internal organization of the syllable. Obviously, S implies C, but not viceversa. For each cited paper I will also indicate the language dealt with. Table 1 provides a synopsis.

There seems to be little doubt, that at post-lexical level, the syllable is a solid cognitive construct. This is proved by a number of experimental results, such as (see fn.1 for the essential details):

- short-term recalling (C): cf. Treiman et al. (1994) /English/;
- sound similarity judgements (C, S): although results differ from language to language, the syllable and its major constituents emerge as powerful predictors of subjects' responses; cf., e.g., Derwing et al. (1992), Derwing & Wiebe (1994), Derwing & Nearey (1994) /Arabic, English, Japanese/;
- possibly, stem-completion (S): the processing level is perhaps the same as that hit by syllable monitoring tasks (Peretz et al. 1996 /French/; however, the syllabic effect seems to emerge only in visual, instead of auditory presentation);
- possibly, lexical decision with intrusion of a non-linguistic sign (S): see Treiman & Chafetz (1987) /English/ (however, as noted above, Levitt et al. (1991) report a partially negative result).[6]

On the other hand, syllabic effects may appear at earlier processing levels. Take for instance blending errors (S; see section 1.1): it is unlikely that, at the point where the production system derails, the two interfering words have already been accessed. By contrast, lexical blends do involve whole words; yet - as we saw above - they do not always yield strong evidence of syllabic conditioning. As to blending tasks, they do provide this sort of evidence (S), but since they consist in the manipulation of non-words, subjects do not act at a post-lexical level, but rather at a post-perceptual stage that entails the operation of short-term memory. This is also true of the following techniques, all of which imply the comparison of a phonological image with the incoming signal, and yield a neat S effect: (i) phoneme monitoring (Segui et al. 1981 /French/,

Treiman et al. 1982 /English/); (ii) segment(s) substitution, at least with English subjects (see section 1.1); (iii) attentional allocation (Pallier et al. 1993 /French/, Finney et al. 1996 /English, but with the complication that stress position exerts a significant effect/).

The use of short-term memory has indeed been explicitly advocated by Levitt et al. (1991) as a necessary prerequisite for detecting syllabic effects. And in fact, as table 1 shows, this seems to be a common denominator in all the cited experimental tasks, with the exception of masked priming of word (and picture) naming, which nevertheless produces a sharp S effect in English (Tousman & Inhoff 1992, Ferrand et al. 1997) and French (Ferrand & Segui 1996), although a negative result is reported for Dutch (Schiller 1998). Yet, even use of short-term memory may not be sufficient, as shown by the behaviour of Italian and Spanish subjects in segment(s) substitution tasks.

Note that syllabic effects have been detected even with fairly short reaction times, as observed in structure induction tasks (Pitt et al. 1998).[7] This is very important, because if syllabic effects emerge at short RTs, this cannot be the reason why syllable monitoring with English subjects fails to yield the expected effect. In fact, as observed by some authors, this negative result may be due to ambisyllabicity, which plays a crucial role in the reactions of English subjects, as shown in particular by Ferrand et al. (1997). Consider a word such as *calory*. According to Rubach (1996), /l/ has all the prerequisites for being perceived as ambisyllabic by English speakers. Thus, supposedly, it is no wonder that subjects get confused, to the effect that an overall advantage for CVC primes emerges, irrespective of the type of word presented (*calory* or *balcony*). Thus, the behaviour of English subjects in this sort of task is not a real problem.

Although the picture is still quite fragmentary, especially with respect to the number of languages investigated through the various experimental techniques, inspection of table 1 (where only a selection of techniques and languages is reported) seems to suggest a possible direction. Namely, it seems to be the case that whenever short-term memory is involved, there is a strong tendency for syllabic effects to emerge, at least in languages like English, which - contrary to the assumptions made by Mehler and co-workers - seem to present an early (indeed, very early) syllabic build-up. The interesting thing is that there does not seem to be a language where syllabic effects emerge in 'early tapping' tasks but not in tasks involving a post-lexical level. This, combined with the fact that the same task may produce alternative results in different languages, lends credibility to the hypothesis that the various languages erect syllabic structure at different levels of on-line processing, and that once this particular level has been reached, the syllable is bound to be a solid cognitive construct. Future research will tell us more about this.

Table 1.

	Processing characteristics			*Languages investigated*					
type of task	post-lex.	s-t mem.	early tap.	Eng.	Dut.	Fr.	Sp.	C / P	It.
lexical decision	+	+	-	+ S					
stem completion	+	+	-			+ S			
short-term recalling	+	+	-	+ S					
sound similarity judgem.	?	+	-	+C, S					
blending	-	+	-	+ S		+ S			+ S
syllable monitoring	?	+	-	(+ S)	+ S	+ S	+ S	+ S	
segment(s) substitution	-	+	-	+ S			- S		- S
phoneme monitoring	?	+	+	+ S					
masked prim. pict. nam.	+	-	-			+			
masked prim. word nam.	-	-	+	(+ S)	- S	+ S			
attentional allocation	-	-	+	(+ S)		+ S			

Legenda: 'C' = core, 'S' = structure; 'C / P' = Catalan and Portuguese; 's-t mem.' = short-term memory; 'early tap.' = early tapping; notations within parenthesis indicate that the effect interferes with other factors, such as ambisillabicity.

3. *The endless game.*

Early build-up? I am pretty sure I already picked up this piece while playing with this puzzle. Typical experience in this sort of game! One keeps finding the same pieces again and again. They often seem to fit into the blank spaces, and repeatedly deceive us, even when we bet we have got a clear intuition of the whole image. The missing pieces - the right ones - continually elude us. Perhaps they are in sight, but we do not notice them. Or am I trying to complete the wrong picture?

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[1] The reader not familiar with the psycholinguistic literature might find it useful to have essential information about this and the other experimental techniques referred to in the paper (note that the term 'stimulus' is neuter between word and non-word):

- ATTENTIONAL ALLOCATION: like 'phoneme monitoring' (see below), except that the target is preceded by a series of stimuli such that the previous targets did or did not occur in the same structural position (e.g., in the Onset);

- LEXICAL DECISION WITH INTRUSION OF NON-LINGUISTIC SIGNS: subjects have to decide about the lexical status of a visually presented stimulus, with the additional complication that a non-linguistic sign (e.g., an asterik) appears in various locations, corresponding to more or less embedded boundaries between (sub)syllabic elements;

- PHONEME MONITORING: subjects have to react as fast as possible by hitting a given key as soon as they identify a given segment in an auditorily or visually presented stimulus;

- SHORT TERM RECALLING: subjects have to recall as many words as possible out of an auditorily or visually presented list;

- SOUND SIMILARITY JUDGEMENTS: subjects have to select, among two auditorily presented pairs of stimuli, the pair whose stimuli intuitively look more phonetically similar to each other;

- MASKED PRIMING OF WORD AND PICTURE NAMING: subjects have to name as fast as possible visually presented stimuli or images after the short presentation of a masked CV or CVC sequence (where masking means that a sequence of non-linguistic signs both precedes and follows the priming sequence);

- STEM-COMPLETION: subjects have to utter as many words as possible that begin with a given sequence of segments, corresponding for instance to an open vs. closed syllable;

- 'SYLLABIC' MONITORING: subjects have to react as fast as possible by hitting a given key as soon as they identify a given CV or CVC sequence in an auditorily or visually presented stimulus;

[2] Needless to say, whenever I speak of English subjects, I mean "English speaking" ones.

[3] Pierrehumbert & Nair (1995) present an alternative view, according to which English phonotactics does not prove that the R-B model is to be preferred to the flat one. The authors contend that output constraints on admissible sequences are better predictors than input ones based on syllabic hierarchy. However, I believe these two positions may be reconciled under the epiphenomenal view of the syllable.

[4] By 'syllabic effect' it should be understood that subjects' responses are speeded up whenever the CV(C) prime matches the initial syllable of the target stimulus.

[5] Similarly, in monitoring tasks Japanese subjects are ostensibly more sensitive to mora than syllabic units, in agreement with the mora-timed character of their language (Otake et al. 1993; Kubozono 1996). The dominant role of the mora in Japanese has also been assessed with other experimental techniques, like 'sound similarity judgements' (Derwing & Wiebe 1994).

[6] As the last example shows, it is not infrequently the case that one and the same experimental technique gives rise to diverging results even with the same language. This invites great caution. In fact, this observation should be generalized to most cells in the right hand-side of table 1: the interpretation reported therein refers to the prevailing, but by no means only, results.

[7] To enhance short latency, these authors used a 'go / no go' procedure, rather than the usual 'yes / no' one. In table 1, this property is indicated as 'early tapping', suggesting RTs of about 500 msec. or less.

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