Syllable structure at different levels in the speech production process
Evidence from aphasia

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Introduction

In the debate between functional and mentalist theories of language, phonology is a particularly interesting language module, for its definite relation to phonetics, the physical side of language. This relation is stronger than for any other aspect of language we have chosen to distinguish, for example syntax or semantics. When we look at phonology from this perspective, this gives rise to the question of what distinguishes phonology from phonetics. The specific question underlying this study is: "To what extent does syllable structure have a phonetic (articulatory) basis?" Adult language deficits can prove to be a good testing ground for this problem, in so far as aphasic patients can be argued to suffer from either a phonological, or a phonetic deficit.

We will present and discuss data of syllable simplifications by different types of aphasic patients. These speech errors are analyzed in terms of a syllabic template, for descriptive reasons. Before we turn to the data, however, Sections 1, 2 and 3 provide discussions of the background this study derives from.

1. Markedness in generative phonology

In the search for universal characteristics of human language, particularly boosted since the Chomskyan revolution of the 1950s and 60s, there has been an ongoing interest in the classification and recognition of linguistic structures
that are more or less ‘marked’ than others (e.g. Chomsky & Halle 1968). What is looked at in studies devoted to the classification of markedness relations, is the relative frequency of certain structures in the languages of the world and in child language. There exist, however, many different views on what the relative markedness of certain structures over others is actually caused by, or what it means. Because of this, the term ‘markedness’ has become quite controversial (Battistella 1990).

Strong believers in an underlying, more abstract representation of spoken language work in a research programme aimed at giving adequate descriptions of this deeper structure. Language in its surface form is considered the window through which underlying linguistic structure can be studied. The basic frame of this underlying structure is maximally simple and universal. It is unmarked. In a simplified version of this view, the child is able to acquire language as fast as it does by starting from the simplest, already present, representation and putting more and more parameters in the complex setting, upon finding complex structures in the input. Languages will have a tendency to be as simple as possible, while still being as fully communicative and subtly expressive as they can be. This conflict has the effect that, although languages differ in their surface representations, the simplest, or least marked structures will be found in most languages of the world, as basic structures will be shared to a greater extent than structures derived but further removed from the universal basis. In fact, in the case of phonology, what is devised most of the time is a markedness hierarchy of structures, in the sense that if a certain complex structure is used in a specific language, all the simpler structures within the same domain will also be present.

The best known example of this is that all languages have been claimed to have consonant-vowel (CV)-syllables, but no languages have only VC-syllables, onsets being less marked than codas (Blevins 1995). Hierarchies of markedness can be considered as scales: a specific structure is not either marked or unmarked, but more marked or less marked, relative to another option. Of course, when only two structures are compared, one can speak of the marked and the unmarked candidate.

It is often suggested that children start their language acquisition (probably after a period of mere repetition) with the most basic, least marked structures (Macken 1995). A well-known proponent of this view was Roman Jakobson, who claimed that the first syllable most children acquire will be /pa/: mouth closed, mouth open. This syllable, then, is regarded as the least marked syllable. Along with this example, Jakobson (1971) goes on to give a markedness hierarchy, apparently based on children’s utterances, but probably also influ-
enced by his view on segments, syllables and phonological structure. It has formed the basis for many linguistic studies.

Jakobson (1971) also claimed that “aphasic regression has proved to be a mirror of the child’s acquisition of speech sounds”. His idea was that the complex structure that human language is, will systematically become less complex when it is damaged, as what is learned last is first to disappear. The more the system is damaged, the more it will resemble the language of a child, using only the least marked forms. This viewpoint has formed the starting point for many research projects, but has proved to be too simple. There are many types of language deficits and the disintegration of language is more complex than was previously suggested. For example, one major difference between children acquiring language and aphasics is that the latter suffer from a deficit in a previously fully operative linguistic system, while the former are systematically building up that system (or getting to know it). The aphasic deficit, or rather the lesion site responsible for the deficit, is not bound by the system itself, as it randomly crosses functionally modular boundaries. Also, people with aphasia are adults who have grown used to many communicative strategies that are relied on in normal language production and perception. Children still have to acquire these strategies, on top of their mother tongue grammar.

Nevertheless, the logic of the general idea behind Jakobson’s statement cannot be simply dismissed, especially if we are able to argue for and distinguish specific functional modules and can study patients with deficits in specific and well-defined language functions.

1.1 A phonetic basis?

If we only look at markedness from the point of view that it is a reflection of more or less ‘simple’ underlying structures, we run the danger of proceeding on the circular track described among others by Liberman (1996:58): “[W]e first determine the mark from usage and then explain usage by markedness.” In this sense, markedness is nothing more than a “theoretical add-on” (Ball 1996). Naturally, any next step in the direction of relevance should be an attempt to give an external explanation for why certain structures are apparently more ‘simple’ than others.

In looking for the factors that determine the markedness of certain structures, for example the CV- over the VC-syllable, phonologists often consider articulatory and/or perceptual characteristics of (combinations of) speech sounds. Note that taking this step is not uncontroversial. Many linguists and phonologists will defend the point that markedness is indeed a reflection of
abstract preferences and basic structure, and that these are not necessarily, or
not at all, related to articulation, perception, or usage. Indeed, perhaps it is the
other way around and the abstract preferences have influenced the relative ease
with which we articulate or perceive certain types of utterance! Points of view
on this matter will mark essential differences between on the one hand, among
others, Natural Phonologists, Gestural Phonologists and Functional Phonolo-
gists, and on the other hand more ‘cognitive’ phonologists (see e.g. Anderson
1981). Of course, most linguists are not easily classified in such general terms.

One of the problems raised by the matter of concrete versus abstract expla-
nations is what we will call the Redundancy Argument. Once the markedness
apparent from the data can be shown to be influenced entirely by articula-
tory or perceptual factors, let us say, the more physical side of language, or
‘phonetics’, the idea of abstract phonological structure is strongly undermined.
This has in fact been the direction in which some phonologists have proceeded
lately. Boersma (1998), for example, shows how certain aspects of phonology
can be acquired without the already present basic framework proposed
by traditional universalists.

However, the discussion on the physical basis of phonological constraints
should not be confused with the present day chasm between behaviourism
and nativism, at least not necessarily (cf. Budwig 1995). It is possible to be a
functional nativist. A highly underspecified Universal Grammar, sprung from
an innate drive to communicate and based on general cognitive possibilities
for structure, may have been moulded by physical and functional constraints,
which have then become internalized to be more effective (Bybee 1994) – as
effective as they are, for example, in child language acquisition. According to
this view, phonetics can be phonologized. This is the ‘way out’ for nativists
who are confronted with more and more functional explanations for linguistic
phenomena. Upon confrontation with those phenomena for which no func-
tional basis can be found, or presented convincingly, it is the way out for
functionalists.

1.2 Different levels

The introduction of multilinear phonology (e.g. Goldsmith 1979) has opened
the door to the idea of markedness relations at different levels of representa-
tion. According to this view, certain phonological features, or feature settings,
are less marked than others, but also combinations of certain features, seg-
ments, are less marked than other combinations. Climbing even further up
the phonological hierarchy, segments may be less marked in certain syllabic
positions, but more marked in others, and certain syllable structures may be
marked word-internally, but unmarked at the edges of words or phrases, or
in stressed positions. This yields multiple markedness hierarchies, which may
sometimes come into direct conflict with each other.

Hierarchies at different phonological levels will not be constituted entirely
similarly. In most theories, for example, features are either on/off (binary fea-
ture theory, e.g. Chomsky & Halle 1968) or present/not present (unary feature
theory, e.g. Harris 1994). This yields either a marked situation or an unmarked
situation for features. As also pointed out by Romani and Calabrese (1998), it is
different for segments, which consist of bundles of features or feature settings,
marked or unmarked. The markedness of segments, therefore, is more rela-
tive than that of features. In the rest of this paper, the focus will be on syllable
structure.

2. Syllable structure

The fact that we discuss syllable structure here, has to do with what we think
syllables are and how we think they are formed. Syllables are the building blocks
of feet, the basic and clearest rhythmical units in language, but they are mostly
regarded as the “structural units providing melodic organization” to phono-
logical strings (Blevins 1995:207). The possible combinations and sequences
of sounds in language are constrained by syllable boundaries. Within those
boundaries, only certain combinations are possible. The possibilities and con-
straints may be general and universal, such that no language will have syllables
starting with /rt-/ , but they may also be language specific, so that syllables
starting with /ml-/ are possible in some languages, but not in others.

From speech error data and psycholinguistic experiments, it has been ar-
gued that syllables are not just chunks of sounds directly connected to the
words that contain them, but that they should be represented as abstract struc-
tural schemas (Stemberger 1990; Sevald et al. 1995; Meijer 1996; Wilshire &
Nespoulous 1997). Sounds are first of all linked to a syllabic structure (CV
structure), specifying what types of sounds are in the syllable and in what order
(e.g. CV, or CVC etc.). The chunk and schematic aspects of syllables may well be
complementary (Sevald et al. 1995), but there has to be a level of representation
where this abstract structure plays its part.

This CV structure is not just of the linear type. Syllables contain a deeper
structure into onsets, nuclei and codas. All syllables must have a nuclear posi-
tion (regardless of whether this position needs to be filled or not), preferably
filled with a vowel. Tautosyllabic consonants in front of the nucleus form the onset, and the consonants following the nucleus make the coda. The nucleus and everything that follows make up the rhyme, so that syllables can also be divided into onsets and rhymes. The latter division is mainly made because stress and tone assignment seem to neglect the segments that make up the onset and depend only on what comes after that.

These syllable constituents can contain more than one segment, and in those cases one element heads the other. Even in frameworks where the syllable itself does not play a part as a phonological constituent (e.g. Harris 1994), this structure is similar. A detailed template of syllabic hierarchical structure may look like the one proposed by Van Zonneveld (1988), based on Cairns and Feinstein (1982) and Van der Hulst (1984):

(1) A syllable template

\[
\text{syllable} \rightarrow \text{onset} \rightarrow \text{rhyme} \rightarrow \text{nucleus} \rightarrow \text{pre-margin} \rightarrow \text{margin core} \rightarrow \text{margin satellites} \rightarrow \text{peak} \rightarrow \text{satellite} \rightarrow \text{coda} \rightarrow \text{appendix}
\]

In this particular model, satellites can only be filled with glides, liquids or nasals (i.e. sonorant consonants), the pre-margin can only be filled with the segment /s/, and the appendix with coronal voiceless obstruents (/l/, /t/) and in very rare cases /k/ or /p/. The pre-margin and appendix positions can be considered extrasyllabic – they violate binary branching and their ‘behaviour’ is exceptional in other ways as well (cf. Harris 1994). Positions dependent on other positions, as the pre-margin and the margin satellite are dependent on the margin core, are only filled if the position they are dependent on is filled. In this model, everything depends on the peak. In terms of markedness, the dependent positions are marked, compared to the positions they are dependent on.

The template as shown in (1) is chosen here solely for its practical advantage, because all specific syllabic positions have names one can refer to. Therefore, it works as a practical aid in the description of the data presented below. It also serves to easily show the various dependency relations present within syllables.
2.1 Cluster Reduction

If a language has consonant clusters, children acquiring this language will reduce these clusters to singletons. A number of studies have shown that this is done quite systematically, especially in onset clusters (Smith 1973; Spencer 1988b; Fikkert 1994; Gilbers & Den Ouden 1994; Paradis & Béland, to appear). The following data are samples from Gilbers and Den Ouden (1994) and from Fikkert (1994). It should be noted that they are gathered from the spontaneous speech and repetition of children and have no statistical basis, except that the linguist's ear was apparently struck by the systematicity in the utterances:

\[
\begin{array}{llll}
\text{(2) a. Child Cluster Reduction (CR), Steven} & \text{(Gilbers & Den Ouden 1994)} \\
\text{age: target: realization:} & \\
1;3 & \text{bloem [blum] 'flower' [bub]} & \\
1;8 & \text{kraai [kraj] 'crow' [kaj]} & \\
1;9 & \text{klok [klk] 'clock' [kok]} & \\
& \text{stool [stul] 'chair' [tuw]} & \\
& \text{broem [brum] onomatopoeia [bum]} & \\
& \text{brroem [brum] onomatopoeia [bum]} & \\
1;11 & \text{trap [trap] 'stairs' [tap]} & \\
& \text{twee [twe] 'two' [te]} & \\
2;0 & \text{schaap [sxap] 'sheep' [be] [xap]} & \\
2;2 & \text{gloria [xlorija] 'gloria' [xotija]} & \\
\end{array}
\]

\[
\begin{array}{llll}
\text{b. CR-data Leonie and Jarno} & \text{(Fikkert 1994:87)} \\
\text{Leonie (1;9) slapan [slapan] 'to sleep' [lapa]} & \\
\text{Jarno (2;3) slapan [slapan] 'to sleep' [lapa]} & \\
\text{Jarno (2;3) slapan [slapan] 'to sleep' [saps]} & \\
\end{array}
\]

We see that in CC onset clusters where the second consonant is more sonorant than the first, the second consonant is systematically deleted (3a). In sC clusters, where the second consonant is an obstruent and thus less sonorant than the fricative /s/, the /s/ is deleted (3b). Interestingly, in sC clusters where the second consonant is a liquid, the difference in sonority is apparently not sufficiently crucial, as children show more variation with respect to the reduction of these clusters (2b; 3c, d).

\[
\begin{array}{ll}
\text{b. sC[-son] → C[-son] /stap/ → [tap]} & \\
\text{c. sC[+son] → s /slap/ → [sap]} & \\
\text{d. sC[+son] → C[+son] /slap/ → [lap]} & \\
\end{array}
\]
These data can be accounted for in various syllable theories, which are of course often based on data such as these. In the template in (1), it is obvious that the margin core position is always retained. sC(liquid) clusters can be represented with /s/ in the premargin and the liquid in the margin core, but also with /s/ in the margin core and the liquid in margin satellite position. This is apparently still optional for the struggling child, hence the error pattern in (2b).

In Government Phonology, with an empty nucleus approach (Kaye et al. 1990; Harris 1994), the representation would be as in (4):

(4) Child Cluster Reduction in Government Phonology

Arrows denote licensing relations. Similarly to the relative positional strength in template (1), the licensor will be retained, and the licensee will be deleted, if the cluster proves to be too difficult for the child.

An Optimality Theoretic account (Prince & Smolensky 1993) of the standard cluster reduction data may look like the tableau presented in (5), where Onset Harmony is a constraint, or a family of constraints, that formalizes the preference for syllable onsets to be as nonsonorous as possible.

(5) Child Cluster Reduction in Optimality Theory

<table>
<thead>
<tr>
<th>klok</th>
<th>No-Complex</th>
<th>Onset</th>
<th>Ons-Harmony</th>
<th>Faithfulness</th>
</tr>
</thead>
<tbody>
<tr>
<td>klok</td>
<td>*</td>
<td></td>
<td>kl</td>
<td></td>
</tr>
<tr>
<td>kra</td>
<td>kok</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>lok</td>
<td></td>
<td></td>
<td>l!</td>
<td></td>
</tr>
<tr>
<td>ok</td>
<td></td>
<td></td>
<td></td>
<td>==</td>
</tr>
</tbody>
</table>

The three markedness constraints dominate Faithfulness. Again, in the case of sC(liquid) clusters, the difference in sonority between /s/ and the liquid might not be sufficiently large for Onset Harmony to be decisive at this stage of constraint (re)ranking by the child.
The above is just to illustrate that the data described and analyzed in sections to come, and especially the (syllabic) level at which they are analyzed, are independent of any specific phonological representation of syllable structure, as long as it incorporates some type of dependency or makes reference to sonority values. The point is that children apparently systematically reduce clusters to singletons, showing a preference to preserve certain prosodic elements over others. The sC(liquid) data show that it is not so much the segmental value of these elements, but their prosodic value, i.e. the syllabic position they occupy, that saves them from deletion.

3. Aphasia

Turning back to the questions posed in section 0, the phonemic paraphasias produced by aphasic speakers may serve as a good test case for the existence of a difference between an abstract level of phonology and a more concrete level of phonetics.

Phonemic paraphasias are speech errors, from which the target word is still recognizable, but in which sounds are substituted, adapted, omitted, transposed or added. The term ‘phonemic’ is somewhat unfortunate, as it refers to a surface level of description, i.e. in terms of phonemes, whereas it is not at all necessarily the case that the erroneous unit is the phoneme, if indeed phonemes exist at all (Harris 1998). This erroneous unit may be a single feature (hence ‘adaptations’), or a syllable node, or one CV- (or X-) slot. With this acknowledged, we will use the term anyway, for its descriptive value, opposed to, for example, verbal paraphasias, in which whole words are substituted.

Patients who produce phonemic paraphasias can roughly be divided into two categories: fluent and nonfluent. In this division, nonfluent patients (often Broca’s aphasics) present with an apraxia of speech and have a problem in the motor programming of a speech plan. It is important to note that they are not dysarthric; their speech apparatus is not paralyzed, but the difficulty lies in the timing and coordination of articulatory movements when speaking (e.g. Blumstein 1991). Patients with an apraxia of speech are characterized by their groping articulatory behaviour in the search for the correct articulation of the sound they want to produce. The number of errors in articulation is correlated with the complexity of the motor task and, through this, with the frequency of occurrence of phonological structures. (Nespoulous et al. 1984, 1987; Caplan 1987; Favreau et al. 1990; Hough et al. 1994; Blumstein 1980, 1991; Code 1998).
Fluent aphasic patients presenting with phonemic paraphasias have normal articulation, but suffer from a deficit in the appropriate selection of phonemes. In a modular model of speech production, their errors originate at a deeper, phonological level of speech planning than the errors of patients with apraxia of speech. When these patients are classified into aphasic syndromes, two major types are fluent: Wernicke’s aphasics and conduction aphasics. Conduction aphasia is characterized by phonemic paraphasias and a relatively (to other modalities) severe repetition disorder, with good comprehension and error-awareness, resulting in many so-called conduites d’approches, repeated erroneous attempts to produce the target word, not necessarily resulting in correct production (Kohn 1984). In several studies, the types of errors produced by conduction aphasics have been shown to be less systematic than, for example, the errors of Broca’s aphasics with an apraxia of speech (e.g. Nespoulous et al. 1984, 1987; Bastiaanse et al. 1994; Favreau et al. 1990). Nespoulous et al. (1984) argued that conduction aphasics do not seem to be looking for a simplification of verbal output, as they found no preference for either the creation or the destruction of consonant clusters in these patients. They are regarded as suffering from a postlexical impairment in the selection and sequencing of phonemes, i.e. a deficit in string construction after lexical access (Kohn 1992; Hough et al. 1994).

Wernicke’s aphasia is characterized by impaired comprehension and semantic and/or phonemic paraphasias in fluent speech. Blumstein (1980, 1991) has found that whereas Broca’s aphasics show timing deficits in Voice Onset Times, Wernicke’s aphasics only show minimal impairment. They mainly have problems in lexical selection.

Analogously to the fluent/nonfluent distinction, runs the distinction between posterior and anterior patients, used, for example, by Blumstein (1991). This categorization refers to lesion sites in aphasic patients, either in the left frontal lobe (Broca’s aphasia), or in the left temporal lobe (Wernicke’s aphasia) or left temporoparietal area (conduction aphasia).

It must be noted that many of the observations given so far in this section are controversial in the neurolinguistic community. Classification in aphasic syndromes is widely challenged, with many arguments for the alternative, a description of symptoms in case studies (e.g. Ellis & Young 1988; Démonet 1998). Also, the quite traditional dichotomy between anterior and posterior aphasic syndromes is challenged (e.g. Crosson et al. 1988). The patients in the present study, therefore, have been selected on the basis of symptoms, rather than syndromes or lesion sites. All patients produced phonemic paraphasias. The nonfluent patients were not or only very mildly dysarthric and suffered
from an apraxia of speech. The fluent patients did not suffer from an apraxia of speech.

Essentially, the assumption from which this study derives is that nonfluent patients producing phonemic paraphasias suffer from a deficit that is related to a phonetic modality, and that fluent patients suffer from a deficit on a more abstract, underlying, phonological level. Even if the latter level can again be subdivided into different levels, it is at least not directly restricted by articulatory factors.

In the domain of syllabic simplification, we will investigate (a) whether, in speech production, fluent and nonfluent patients show effects that can be related to syllabic markedness as it was laid out in section 2, and (b) whether the effects are similar in both types of patients, phonetically and phonologically impaired.

4. Method

4.1 Subjects

Fifteen aphasic patients participated in this study. All were native speakers of Dutch. The group of nine fluent patients consisted of two females and seven males, with a mean age of 58 (range: 38–84). The nonfluent patients were six: four female and two male, with a mean age of 62 (range: 50–79). The nonfluent patients were diagnosed by their speech therapists and both authors as having an apraxia of speech in the absence (as far as this can be established) of a ‘deeper’ phonological deficit. The fluent patients do not have apraxia of speech. All patients produced phonemic paraphasias in spontaneous speech.

4.2 Materials

A repetition task was constructed, consisting of 114 Dutch monosyllabic words. The syllabic structures tested in these items are listed in (6). The (binary) sonority values of consonants are indicated with [+/-son] where necessary. This indication is not given where it is redundant, as for example in CC onset clusters, where the first segment is a nonsonorant and the second a sonorant consonant in Dutch.
(6) **Syllable structure categories**

<table>
<thead>
<tr>
<th>Category</th>
<th>Structure</th>
<th>Example</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset singleton structures:</td>
<td>C[-son]V(C)</td>
<td>tak</td>
<td>/tak/</td>
</tr>
<tr>
<td></td>
<td>C[+son]V(C)</td>
<td>lak</td>
<td>/lak/</td>
</tr>
<tr>
<td></td>
<td>sV(C)</td>
<td>sik</td>
<td>/sik/</td>
</tr>
<tr>
<td>Onset cluster structures:</td>
<td>CCV(C)</td>
<td>trap</td>
<td>/trap/</td>
</tr>
<tr>
<td></td>
<td>sC[-son]V(C)</td>
<td>stap</td>
<td>/stap/</td>
</tr>
<tr>
<td></td>
<td>sC[+son]V(C)</td>
<td>smak</td>
<td>/smak/</td>
</tr>
<tr>
<td></td>
<td>sCCV(C)</td>
<td>strik</td>
<td>/strik/</td>
</tr>
<tr>
<td>Coda singleton structures:</td>
<td>(C)V[C[-son]}</td>
<td>pak</td>
<td>/pak/</td>
</tr>
<tr>
<td></td>
<td>(C)V[C[+son]}</td>
<td>pαn</td>
<td>/pαn/</td>
</tr>
<tr>
<td></td>
<td>(C)V{s</td>
<td>kas</td>
<td>/kas/</td>
</tr>
<tr>
<td>Coda cluster structures:</td>
<td>(C)V[C[+son]}</td>
<td>park</td>
<td>/park/</td>
</tr>
<tr>
<td></td>
<td>(C)V[C[+son]}</td>
<td>hars</td>
<td>/hars/</td>
</tr>
<tr>
<td></td>
<td>(C)V{s</td>
<td>fiets</td>
<td>/fiets/</td>
</tr>
<tr>
<td></td>
<td>(C)V{s</td>
<td>mast</td>
<td>/mast/</td>
</tr>
<tr>
<td></td>
<td>(C)V[C[-son]}</td>
<td>pact</td>
<td>/pact/</td>
</tr>
<tr>
<td></td>
<td>(C)V[C(C)CC</td>
<td>herfst</td>
<td>/herfst/</td>
</tr>
</tbody>
</table>

The bold face structures appear both in onsets and codas, though mirrored. In comparisons between onsets and codas, only these structures have been analyzed, as it would be unrealistic to compare numbers of errors made in the coda of a word such as *pact* (‘pact’; CVC[-son]C) with numbers of errors made in the onsets of words such as *trap* (‘stairs’; CC[+son]VC). In comparisons within constituents (onsets and codas) all structures have been analyzed.

Although there are advantages to the use of nonwords over real words in this type of experiment for reasons of item control, a very strong disadvantage is that some patients have particular problems related to nonwords. For conduction aphasics, it is sometimes quite impossible to repeat a word without being able to process it via a 'lexical route.' This may result in neologisms or silence, both of which are of no use to this study.

### 4.3 Procedure

Items were read from an ordered list, by one of the two authors. During the repetition task, the mouth of the researcher was shielded with the item list, so that subjects were not aided by the visible articulatory movements of the person in front of them, reading the stimuli.
4.4 Scoring and analysis

Scoring was done per syllable position, where positions were based on the template in (1). Basing the positions on this template in the data matrix was mainly done for descriptive and thus practical purposes. The results as categorized would have been no different had we used, for example, the prosodic structure proposed by Harris (1994), in the framework of Government Phonology. It yields similar predictions in prosodic simplification. Indeed, both representations are of course based on the same general observations in natural language.

Neologisms, semantic paraphasias and “no response” responses (32 in total) were not taken into account, resulting in a total valid stimulus number of 1678. Also, the errors on vowels (86 errors in 1678 utterances, or 5.1%) were not taken into consideration in this study. Only errors on consonants were scored. Many of the possible deletions in our target stimuli would result in existing words, and technically such errors would be verbal paraphasias. However, we have chosen to treat these errors as phonemic paraphasias, accidentally resembling verbal paraphasias. They were not treated any different from other valid responses.

In this study, only deletions were considered, as they are clearly a simplification of the output in absolute terms.6 Note that it is essentially not the question here whether and which aphasic patients simplify syllable structure, but rather which syllabic positions are most vulnerable in the case of simplification.

Only the first attempts of patients were considered. Wilcoxon tests were conducted on the proportions of deletions in different syllable positions present in target items. Proportions were derived from the total number of occurrences of a position in the original targets, so that additions did not raise the total number, and thus lower the proportion of deletions.

5. Results

In the results presented below, significance is established at p < 0.05. Probability values follow from two-tailed Wilcoxon tests on the individual scores of patients. For the sake of readability of this article, we have chosen to present only the values of significant differences in the text, while all other z- and p-values are listed in Appendix A.

All graphs show the average percentages of deletions in a certain position, relative to the number of times the position is filled in the target word. In the graphs, PREMAR means `premargin'; MARCOR means 'margin core';
MARSAT means ‘margin satellite’; and CODSAT means the ‘sonorant coda position’.

5.1 Onsets vs. codas

Figure (7) shows the average percentages of deletions in onsets and codas of fluent and nonfluent patients. Both groups of patients make more errors in codas than in onsets.

(7) Onsets vs. codas per group

For fluent patients, this difference is significant (\(z = -2.240; p = 0.025\)), but for nonfluent patients it is not (\(z = -0.524; p = 0.6\)).

5.2 Positional effects within clusters

Figures (8) and (9) show the average percentages of deletions per position of the fluent patients and the nonfluent patients.
For the fluent patients, the following effects are significant:

I. more deletions of the margin satellite than of the margin core ($z = -2.197$; $p = 0.028$)
II. more deletions of the appendix than of the coda position ($z = -2.666$; $p = 0.008$)
III. more deletions of the appendix than of the sonorant coda position ($z = -2.310$; $p = 0.021$)

For the nonfluent patients, significance is reached for the following effects:

I. more deletions of the margin satellite than of the margin core ($z = -2.201$; $p = 0.028$)
II. more deletions of the appendix than of the coda position ($z = -2.201; p = 0.028$)

The great average percentage of deletion errors in the premargin of nonfluent patients is mainly caused by one patient in that group, who produced a deletion error in 94.4% of the time this position occurred in the target word. As the Wilcoxon test takes into account the individual scores of the subjects, the difference between the premargin and the margin core, which is quite striking in the graph, proves not to be significant for the nonfluent patients. The difference between the sonorant coda position (CODSAT) and the 'normal' coda position does not reach significance for either group. Particularly the nonfluent patients, however, have a tendency to delete the coda satellite position, for example filled with /n/ in 'print'.

5.2.1 Consonant clusters in onsets
In order to investigate the relative vulnerability to deletion of different syllabic positions in more detail, we will now focus on specific consonant clusters. This also provides us with a chance to analyze the data with even less dependence on the syllabic representation on which we have chosen to model our target items. In the following graphs, the bars belonging to positions that template (1) predicts to be weak are light, and the strong positions are dark.

Figure (10) shows the average percentages of deletions of both groups of patients in CC onset clusters, of the type 'plot'.

(10) Deletions in CC onsets

For both fluent ($z = -2.032; p = 0.042$) and nonfluent ($z = -2.041; p = 0.041$) subjects, the effects are significant: more deletions in the margin satellite.
Figure (11) shows the average percentages of deletions in sC[−son] onset clusters, of the type ‘stap’. Neither of the differences is significant.

(11) Deletions in sC[−son] onsets

Average percentages of deletions in sC[+son] onset clusters, of the type ‘slap’, are depicted in Figure (12).

(12) Deletions in sC[+son] onsets

Neither of the differences is significant.

Figure (13) depicts the average percentages of deletions in sCC onset clusters, of the type ‘straf’. Again, none of the differences is significant.
5.2.2 Consonant clusters in codas

Figure (14) shows the percentages of deletions in C[+son]C codas, of the type 'park'. For the fluent patients, the sonorant coda position and the coda position are equally vulnerable to deletion. Nonfluent patients show a tendency to delete the segment in the sonorant coda position more often than that in the coda position.

(14) Deletions in C[+son]C codas

If the second consonant in this type of onset cluster is /s/, as in 'hars', the picture is the same (Figure (15)).
(15) **Deletions in C [+son] s codas**

Coda clusters of type C[-son]s ('muts') are represented differently in the model, as they violate the sonority hierarchy (when regarded as one syllable). C[-son] is placed in the coda position, and /s/ in the appendix. Average percentages of deletions in these positions are shown in Figure (16).

(16) **Deletions in C [−son] s codas**

Neither of the differences in Figure (16) reaches significance.

Figure (17) depicts the average percentages of deletions in sC coda clusters, of type 'nists', where, in our model (1), /s/ is placed in the coda position and the following consonant in the appendix.
Fluent patients produce significantly more deletions in the appendix position than in the coda position \((z = -2.588; p = 0.01)\), but this is merely a tendency \((z = -1.604; p = 0.109)\) for nonfluent patients.

\(C[-son]C\) coda clusters, of type ‘pact’, which have the same representation, evoke similar effects, depicted in Figure (18).

Again, the effect is significant for fluent patients \((z = -2.527; p = 0.012)\), but not for nonfluent patients \((z = -1.581; p = 0.114)\).

The category of \((C)VC(C)CC\) codas was not regarded and analyzed as one homogeneous group, because it consists of words that vary in their representation, such as ‘herfst’ and ‘markt’. The first of these two examples has
two segments in the appendix, whereas the second only has one segment in that position.

6. Discussion

None of the significant effects or the nonsignificant tendencies found in the fluent and nonfluent aphasics’ utterances is in the opposite direction as could be expected from the syllabic representation used, which is based on, among others, child cluster reduction data and phonological structures and processes gathered from languages of the world.

In some cases, the lack, or weakness of effects is noteworthy. The premargin position, occupied by /s/ in, for example, ‘step’ proves not to be as vulnerable to reduction as might be expected from its representation. /s/ violates the sonority hierarchy in this position. In Government Phonology (e.g. Harris 1994) it belongs to a previous syllable, licensed by the consonant that follows it (/t/ in ‘step’). Also, when /s/ is less sonorant than the following consonant in an onset, as in ‘slap’, there are only tendencies for both groups of patients to delete the second consonant, which, in our model (1), is indeed a dependant of /s/ in the margin core position. All tendencies are in the direction of less marked structures, but perhaps /s/ appears to behave with somewhat more variability than other types of consonants in the onset. In section 2.2, we saw that sC[+son] onset clusters also appear to lead to more variable behaviour in children reducing clusters.

Regarding the sC[+son] onset clusters, with /s/ in the margin core, fluent and nonfluent aphasic speakers behave quite similarly, with respect to the relative (nonsignificant) difference between margin core and margin satellite positions, with more deletions in the satellite position. With respect to sC[−son] onset clusters, with /s/ in the premargin, the effects of both groups are in the direction of more deletions in the premargin, as expected from the perspective of positional markedness, but these effects are not significant, and for the fluent group it is very small.

In codas, fluent patients make an equal amount of deletions in the sonorant coda position (the coda satellite) as in the coda position, while nonfluent patients have a tendency to delete the sonorant coda position (/n/ in ‘print’) more often. Phonological theory is less straightforward regarding the relative markedness of codas, than it is for onsets. From template (1) and the Government Phonology representation in (19), we would expect /t/ in /print/ to be stronger than /n/. 
In this representation, /n/ is licensed by /t/, the nucleus, and by /r/, the following onset, which also properly governs /n/ (Harris 1994:168). A licensee is naturally expected to be weaker than its licensor.

However, Clements (1990) claims that codas do in fact have a ‘preference’ to be sonorant, which makes /ptron/ less marked than /ptn/. This Sonority Dispersion Principle is in disagreement with, for example, Donegan and Stampe’s (1978) Theory of Maximal Contrast (cf. Christman 1992b; Romani & Calabrese 1998). The claim is based on an analysis of the frequency of structures that are present in languages in the world. From a purely segmental perspective, most phonologists would argue that in the domain of consonants, the least sonorant consonants are the least marked and the more sonorant consonants are more marked. From a prosodic perspective, however, it may be the case that more sonorant consonants in codas are preferred over less sonorant consonants (cf. section 1.3). Possibly, this conflict in codas leads to the balance in the results of fluent patients when the sonorant positions are compared with the nonsonorant positions. In onsets, the conflict does not exist, because onsets have a preference to be as nonsonorant as possible, according to both the Sonority Dispersion Principle and the Theory of Maximal Contrast.

Apart from these two effects, or non-effects, both groups of patients behave similarly and as expected from the syllabic representation used as a background to this study, whether in tendencies or significant effects. This deals with our two questions as stated at the end of section 3. In light of the discussion about phonetics versus phonology, these results give rise to the claim that syllable structure, with positional prominence relations, does not only play a role at the articulatory (phonetic) level, but comes into play on an earlier, phonological level in the speech production process. Of course, this does not mean that the structures present at both levels have to be independent. It seems rather the case that the two levels are highly interdependent, where either articulatory constraints have influenced phonological representation, or, as theoreti-
cally possible but less likely, the other way around. To us, these results provide a hint in the direction of functional nativism as described in section 1.2.

A big ‘however’ says that patients with an apraxia of speech may not have an articulatorily based, or phonetic problem at all. Studies have indeed indicated before that apraxia of speech may be more of a phonological problem, where errors are highly influenced by underlying phonological representations (e.g. Dogil & Mayer 1998). Code and Ball (1988), for example, argue for a phonetology, with a phonological component, a cognitive phonetic component and an articulatory phonetic component. Apraxia of speech, in this theory, is an impairment at the cognitive phonetic component. Although these authors specifically argue that markedness reflects articulatory properties and not linguistic ones, the data presented here at least show that markedness effects are present both at the phonological level and at the (cognitive) phonetic level. Neurolinguists are still debating (Code 1998).

7. Conclusion

We have reported on a study into the treatment of syllable structure by phonetically and phonologically impaired aphasic patients. Regarding the relative similarity of the error types of both groups of patients it was argued that syllable structure plays a part in an early stage of the speech production process, but that it also has an articulatory basis. Syllable markedness effects cannot only be considered a direct result of articulatory factors, as the hierarchic structures responsible for the effects must also be present at a more abstract, underlying level of processing.

Notes

1. Or, alternatively, by giving greater power to constraints that allow the output to be more complex, so as to match it to the surface form of the language the child is acquiring.
2. More specifically, not having an onset filled with segmental material makes a syllable more marked, or less likely to occur than syllables in which the onset is filled.
3. From a segmental, or rather featural perspective, the first syllable should be /tə/), as the coronal place of articulation of /t/ is generally considered the least marked and therefore default candidate.
4. A simplification, here, is literally a reduction in the number of phonemes, or articulatory gestures the subject has to make. In this terminology, a simplification may lead to a more
marked structure, where for example a CVC syllable is reduced to a VC syllable, 'lacking' an onset. Similarly, addition of a segment may result in a less marked syllable structure, as, for example, with the addition of a vowel within a complex onset (/trep/ → [trep]). However, this would not constitute a reduction in absolute terms.

Appendix A

**Onsets versus codas (Figure (7)):**
- Fluent: $z = -2.240; p = 0.025$
- Nonfluent: $z = -0.524; p = 0.6$

**Positional effects all syllables**
- Fluent patients (Figure (8))
  - PREMAR vs. MARCORE:
    - $z = -1.753; p = 0.080$
- MARCORE vs. MARSAT: $z = -2.197; p = 0.028$
- PREMAR vs. MARSAT: $z = -1.439; p = 0.15$
- CODSAT vs. CODA: $z = -1.120; p = 0.263$
- CODA vs. APPENDIX: $z = -2.666; p = 0.008$
- CODSAT vs. APPENDIX: $z = -2.310; p = 0.021$

**Nonfluent patients (Figure (9))**
- PREMAR vs. MARCORE:
  - $z = -1.572; p = 0.116$
- MARCORE vs. MARSAT: $z = -2.201; p = 0.028$
- PREMAR vs. MARSAT: $z = -0.524; p = 0.6$
- CODSAT vs. CODA: $z = -1.153; p = 0.249$
- CODA vs. APPENDIX: $z = -2.201; p = 0.028$
- CODSAT vs. APPENDIX: $z = -1.363; p = 0.173$

**CC onsets, trap (Figure (10))**
- Fluent: $z = -2.032; p = 0.042$
- Nonfluent: $z = -2.041; p = 0.041$

**sCC onsets, straf (Figure (13))**
- Fluent
  - PREMAR vs. MARCORE:
    - $z = -0.412; p = 0.680$
- MARCORE vs. MARSAT: $z = -1.511; p = 0.131$
- PREMAR vs. MARSAT: $z = -1.577; p = 0.115$
- Nonfluent
  - PREMAR vs. MARCORE:
    - $z = -0.378; p = 0.705$
  - MARCORE vs. MARSAT: $z = -0.813; p = 0.416$
  - PREMAR vs. MARSAT:
    - $z = -0.135; p = 0.893$

**C[+son]C codas, park (Figure (14))**
- Fluent: $z = -0.378; p = 0.705$
- Nonfluent: $z = -1.414; p = 0.157$

**C[+son]s codas, mals (Figure (15))**
- Fluent: $z = -0.108; p = 0.914$
- Nonfluent: $z = -1.134; p = 0.257$

**C[–son]s codas, muts (Figure (16))**
- Fluent: $z = -0.984; p = 0.325$
- Nonfluent: $z = -1.483; p = 0.138$

**sC codas, mist (Figure (17))**
- Fluent: $z = -2.588; p = 0.01$
- Nonfluent: $z = -1.604; p = 0.109$

**C[–son]C codas, pact (Figure (18))**
- Fluent: $z = -2.527; p = 0.012$
- Nonfluent patients: $z = -1.581; p = 0.114$. 

References


