

Recursive Patterns in Phonological Phrases

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Abstract

In this paper we investigate an instance of phonological recursion, more specifically we investigate iterative rule application in phonological phrases. The question is whether or not edge-marking processes, such as early pitch accent placement, can be applied recursively to phonological phrases that are embedded in larger phonological phrases.

1. Overview

In Section 2 we present the background theory about recursion and we state the research question. Section 3 describes our experiment and the data, and the discussion and conclusion make up Sections 4 and 5.

2. Recursion

Recursion is a very common phenomenon in syntax. It refers to rules, which are capable of repeated application in generating a sentence. There is, for example, no limit to the number of adverbs, which may modify a verb: *Aretha sang sweet, breathy and soulful in "Ain't no way"*. Furthermore, there is in principle no limit to the number of preposition phrases that may occur after a noun in a noun phrase: *the American in the desert on a horse with no name* and you can always add a sentence to a sentence within a sentence as exemplified in the present sentence. As Crystal (p.292) puts it in [3], the application of recursive rules is the main formal means of accounting for the creativity of language: by using this device, an infinite set of sentences can be generated from a finite set of rules.

In phonology, things seem to be different. Although iterative rule application is proposed for e.g. foot assignment, prosodic building rules seem to be limited in that sense. One cannot freely add e.g. onsets or nuclei to a syllable or syllables to a prosodic word. One of the rare occurrences of the incorporation of a prosodic domain within the same prosodic domain can be found in Selkirk [16], [17], who proposes a syllable within a syllable, a so-called *super-foot*, in order to account for dactylic patterns in rhythmic structures. Not only is this incorporation limited to the representation of ternary feet: alternative representations for these patterns can be found in Dresher and Lahiri [4], who propose a ternary branching tree, and Kager [11], who maintains binarity and leaves the third syllable unparsed.

The limitations to the prosodic hierarchy are reflected in the Strict Layer Hypothesis [17], of which one of the fundamental assumptions is that prosodic structure is not recursive. A mismatch thus exists between syntactically recursive constituent structure and the linearly segmented structure in prosody.

The Strict Layer Hypothesis has been criticized. Several phonologists, [10], and papers in [8], have shown that in many cases it is violable; the assumption of non-recursivity has been challenged by a number of authors, in particular involving prosodic words with affixal clitics, [10], [23], a.o., but also in larger prosodic domains like the intonational phrase (see [12], and references therein). These phenomena led Selkirk [19] to replace the Strict Layer Hypothesis with a series of four separate constraints, one of which is Nonrecursivity: No C_i dominates C_j , $j = i$.

Since recursion is very common in syntax, the primary source of evidence for instances of recursion in phonology is probably provided by phonological rules that operate over syntactically defined (recursive) domains. The phonological phrase is one instance of a domain of which the phrase breaks typically coincide with the edges of morphosyntactic phrases [17], [14]. Although there is no consensus on what exactly constitutes the phonological phrase, we follow Selkirk, who assumes that the phonological phrase aligns with either the left or the right edge of the head of a maximal projection which is not lexically governed, i.e., it groups a phrasal head together with its adjacent modifiers and functional elements [19].

2.1. Research question

In this paper we will show that recursion can also be found at these higher domains in the prosodic hierarchy. To investigate this, we examined various Dutch phonological phrases (or in Selkirk's terms: Intermediate Intonational Phrases), consisting of either a noun modified by one adjective, of the type *aardrijkskundig genóotschap* 'geographical society', or by two adjectives, of the type *Amsterdams aardrijkskundig genótschap*, i.e., a recursive noun phrase (the accents on the adjectives indicate the main stress position in citation form.). Syntactically, this kind of phrase can in principle be infinitely extended with adjectives: [voormalig [onafhankelijk [Amsterdams [aardrijkskundig genótschap]_{NP}]_{NP}]_{NP}]_{NP} 'Previously independent Amsterdam geographical society'.

The first type of phonological phrases is known to display early pitch accent placement [20], [21] as a means of signalling a phrasal boundary to give the listener a cue to the prosodic structure of the spoken utterance. This phenomenon was first referred to as Iambic Reversal [13], and it is also known as stress shift, or the Phrasal Rule [9]. Shattuck-Hufnagel [20] and Shattuck-Hufnagel, Ostendorf and Ross [21] have shown that the phenomenon is not movement of lexical main stress, but a combination of two events: the occurrence of a phrase-level intonational prominence on the earlier full-vowel syllable, and the non-occurrence of a pitch accent on the later main-stress syllable.

The question now is what kind of prosodic structure has to be assumed for the second type, the syntactically recursive noun phrases. If the non-recursivity assumption holds and these phrases are non-recursive, then they must have a flat, linear structure, and no early pitch accent will occur on the second adjective: [Àmsterdams aardrijkskundig genóotschap]. But if, on the other hand, an early pitch accent can be realized on this second adjective, we have to assume a nested, recursive phrase structure, indicating two left boundaries within the same phonological phrase, i.e. a nested prosodic structure: [[Àmsterdams [aardrijkskundig genóotschap]]. Selkirk herself [18] gives some examples of this kind in English: [[nôrthern][Càlifornia wínes]] as opposed to the right-branching phrase [[nôrthern Calìfòrnia] wínes], but without going into its recursivity. We hypothesize that these syntactically recursive noun phrases can be realized as recursive phrases in prosody as well.

To investigate whether these kind of phonological phrases can indeed be produced with a recursive prosodic structure, with the Phrasal Rule applying two times, we conducted an experiment, which is described in the next section.

3. The experiment

3.1. Design

In order to get as close to spontaneous speech as possible, we used the Map Task [2] to build our corpus in a controlled way. The Map Task originally is a cooperative task involving two participants, used to build dialogue corpora. We adapted the original design somewhat to our own requirements. The subject and the experimenter sat opposite one another, the subject sat in the soundproof studio behind a glass window, and each had a map which the other could not see. The subject had a map consisting of a starting point, an endpoint and some landmarks, labeled with their names, on the route. The phrases of interest were the landmarks, the rest were fillers. The experimenter's map only had the starting point drawn on it.

We made fifty different maps, with two landmarks of interest on each map, which makes hundred phrases in total. Each map had four fillers and the phrases of interest never appeared as a starting point or end point. Each map contained one syntactically recursive phrase landmark [Adj [Adj Noun]] and one non-recursive, non-corresponding phrase landmark [Adj Noun]. The subjects never saw two corresponding phrases.

3.2. Subjects

We tested 24 subjects, ten men and fourteen women, aged 19 to 28. Most of them were law students, with Dutch as their mother tongue. Ten subjects were brought up in the northern provinces of the Netherlands, nine of them came from the center, three from the west and two from the south. One subject had grown up in the Netherlands Antilles, and Dutch was not her mother tongue, though she learned it in her childhood. We found no differences in the characteristics of interest, so we kept her in the experiment. The subjects were unaware that it was a linguistic experiment.

3.3. Method

The subjects were told that their goal was to lead the experimenter from point A to point B on the map, leading past all landmarks on the map, and they were supposed to mention all the landmarks they came across. An example of a question is: *"We are at Pizzaria Florence and I want to go to the Newspaper of the West. Can you tell me the way?"* They then explained the route in the following way: *"Ehh, if you are at Pizzaria Florence, - then you walk ehh straight ahead, - you take the first turn right, - then you walk straight ahead, - at the crossroad you walk straight ahead again, then ehh you take the first turn right, - [...] then you keep on walking straight ahead, then you seehhh - on your left hand the building of Amsterdam Geographical Association, [...] etc."* (This is a translated fragment of a route description by subject V06.)

The experimenter did not interfere. Afterwards the subjects were asked to read the adjectives aloud in citation form, within the sentence *Ik spreek nu het woord ... uit* 'I now pronounce the word ...'.

All data were recorded with a Sennheiser MKH 40 Microphone (mono), on a Sony DTC-57ES DAT-recorder, with Fuji Digital Audio Tapes. The sound files were digitalized with Cool Edit Pro at a 22050 Hz sample rate, mono with 16-bit Resolution, normalized to 100%, and saved as .wav files (Windows PCM). The phrases of interest were extracted from the sound materials; the same procedure was used for the citation form words.

For the analysis three trained listeners judged the data auditorily and indicated on which syllables in the adjectives they perceived word accent. They were free to indicate more than one accent per adjective, which meant that words could be double pitch accented. A majority judgement of the three trained listeners was decisive, but it turned out that there was consensus among the three listeners on almost all data. We ran Chi-Square tests on the statistics.

3.4. Data

As pointed out above, the data consisted of one hundred phonological phrases, half of which were Adjective - Noun combinations and the other half were corresponding Adjective - Adjective - Noun combinations. Table 1 shows a selection of our data. Some examples can be downloaded as MP3-files from <http://odur.let.rug.nl/~schreudr/papers.htm>.

In order to minimize the influence of pure regular rhythm instead of prosodic structure, for example eurhythmicity effects of the Quadrisyllabic Rule [9], we varied the number of syllables between the accentable positions in the words from 1 to 7. We also avoided stress clash effects, and contrast affects of phrases ending in a similar suffix or contrasting phrases on one map.

The type of phrases we used has the name Rhetorical Retraction [5], because rhetoricity plays an important role. Van Bezooijen [22] a.o. shows that speakers use Rhetorical Retraction most in propagandistic speech. In order to show that it is not only a stylistic phenomenon, but also a structural device, we made the speech context as neutral as possible. With the map task we were guaranteed a non-commercial, neutral context.

Table 1: Data

<i>Aardrijkskundig genootschap</i>	'geographical society'
<i>Amsterdams aardrijkskundig genootschap</i>	'Amsterdam -'
<i>Diplomatieke organisaties</i>	'diplomatic organizations'
<i>Internationale diplomatieke organisaties</i>	'international -'
<i>Regionale dagbladers</i>	'regional day-paper press'
<i>Algemene regionale dagbladers</i>	'general -'
<i>Socialistische partij</i>	'socialist party'
<i>Progressieve socialistische partij</i>	'progressive -'
<i>Psychiatrisch ziekenhuis</i>	'psychiatric hospital'
<i>Academisch psychiatrisch ziekenhuis</i>	'academic -'

We divided the subjects over five different map sets, so each subject read ten maps, which means ten recursive and ten non-recursive phrases each subject. This resulted in about 550 spoken phrases in total. An impressionistic observation reveals that the subjects mostly pronounced the names of the landmarks in focus, and most of the times it was before a comma with a pause, pronounced with a so-called continuation rise (L-H%) or before a full stop, with the so-called declarative contour (L-L%) [15], [7]. Some subjects sometimes repeated the phrases. The repetition was then most of the time out of focus and sometimes with a different rhythmic pattern. Others unfortunately missed some of the phrases. In the results section we only report single utterances of a phrase for each subject.

3.5. Results

The three trained listeners indicated where they perceived pitch accents on the adjective in the non-recursive phrases and on each of the two adjectives in the recursive phrases. When a majority indicated they perceived a pitch accent on a certain syllable, this syllable was appointed a 1, the other potential pitch accent site was appointed a 0. In most of the cases the listeners agreed on the pitch accent position. Figures 1 and 2 show the percentages of pitch accents perceived on the early syllable, the main stress position, and also the percentage of the cases that were judged to be double accented. Figure 1 depicts the results of the non-recursive phrases, Figure 2 the results of the recursive phrases. The second group of bars in Figure 2, called Adjective 2, represents the same adjectives as the bars in Figure 1.

The two graphs clearly show that, although there is a strong preference for the subjects only to accent the main stress syllable, early accent placement is also a strong tendency. For the non-recursive phrases 52% displayed an early pitch accent. This is even a higher percentage than Van Bezooijen reports in [22] for the rhetoric expressions, about 30%, while we had a totally neutral context. This already is a surprising result.

The most interesting result for this study, however, is the early pitch accent bar of the second adjective of the recursive phrases in Figure 2. Although these were not the initial words of the longer phonological phrases, they still received an early

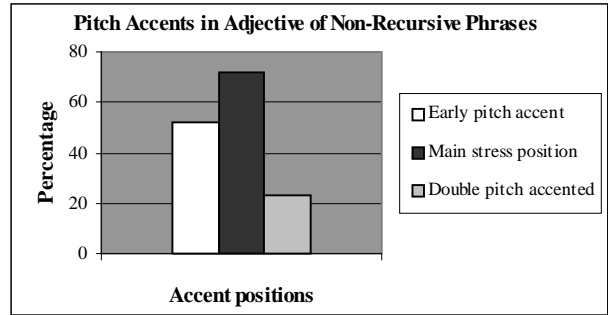


Figure 1: Percentages of perceived pitch accents on the adjective in the Non-Recursive phrases (N = 238)

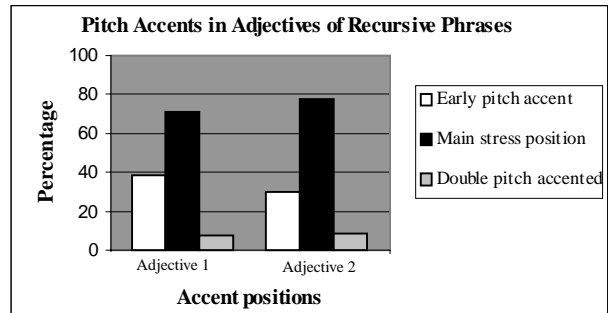


Figure 2: Percentages of perceived pitch accents on the two adjectives in the Recursive phrases (N = 232)

pitch accent in 30% of the phrases. This result seems to confirm our hypothesis that these syntactically recursive phrases can also be recursive prosodically.

On the recursive phrases we have to make a remark about the first adjective. These first adjectives had in 17 phrases the main stress position on the early syllable, which means that the pitch accent was fixed and was not expected to shift. This was not a problem, because we were mainly interested in the second adjective. Therefore we assigned this pitch accent of these 17 first adjectives to the main stress position, and this may be the reason that the bar of the early pitch accent is lower (38%) than the first bar in the graph in Figure 1, besides the fact that these were different words.

Subjects and items differ greatly in their behavior and patterns, however. The standard deviations are very large or even maximal for the items. This means that some items never conformed to the Phrasal Rule, and others, on the other hand, always did.

Besides these subject- and item dependencies, Pearson Chi-Square tests show that the proportions of early pitch accents and main stress positions in the phrase and in citation form are significantly different (χ^2 (df 1) = 122.524, $p < 0.001$). Also the difference between the proportions of corresponding adjectives of the non-recursive and recursive phrases is highly significant (χ^2 (df 1) = 12.326, $p < 0.001$).

Note that the Chi-Square value of the non-recursive vs. recursive test is much smaller than the value of the phrase vs. citation form test, which indicates that the difference between the patterns of the corresponding adjectives in phrase-initial and phrase-second position are much smaller than the differences between the adjectives spoken in phrase-second position and in citation form. The adjectives in citation form

had a nearly 100% score of pitch accents in main stress position.

Another interesting finding is the relatively high percentages of double pitch accents on adjectives in the phrase, i.e., a pitch accent both on the early syllable and the main stress position of the word. Shattuck-Hufnagel reports a similar finding in [20]. This can be seen as extra evidence for the idea that the process underlying the Phrasal Rule is not stress shift, but an additional pitch accent, which can cause the main stress position to get deaccented [6].

4. Discussion

The results of this experiment show that the prosodic recursion-hypothesis holds: recursion does exist in prosody. But they also show that the embedded phonological phrases, e.g. *aardrijkskundig genootschap*, do not behave identically to the maximal phonological phrases, e.g. *Amsterdams aardrijkskundig genootschap*, in the sense that the maximal phonological phrases are early accented significantly more often. Clearly, there is a lot of optionality involved. On the basis of these results we cannot decide whether this shows that it is the recursive structure which is optional, or that it only reflects the optionality of early pitch accent placement, but it seems to be the case that both can be optional. The results confirm the observation that there is no one-to-one mapping from syntax to prosody, because optionality in syntactic structure would not be an option.

We have not found clear indications as to which factors have an influence on the option for a certain word to receive an early pitch accent or not.

5. Conclusion

Various phonologists have shown that prosodic structure is signalled by a variety of boundary-marking phenomena, and that early pitch accent placement is the ultimate signal for a phonological phrase boundary. This observation is confirmed by our data, but moreover, we have shown that prosodic structure is less linear than assumed in the Strict Layer Hypothesis and derived hypotheses. In 30% of our data, the second adjective in a syntactically recursive noun phrase received an early pitch accent, and therefore it is reasonable to assume that these phrases were recursive prosodically as well. In other words, the results of our experiment must be understood as additional evidence for a more prominent place for recursion in phonology.

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