

RELATING PROSODY TO SYNTAX: BOUNDARY SIGNALLING IN SWEDISH

Eva Strangert

Department of Linguistics, Phonetics
Umeå University, S-901 87 Umeå, Sweden
Tel: +46 90 165680, Fax: +46 90 166377, E-mail: strangert@ling.umu.se

ABSTRACT

Two factors were experimentally varied in order to study their effects on silent interval and segment duration at NP-VP boundaries in Swedish sentences. These factors, the syntactic complexity of the NP and VP portions as well as the length of the words in the sentence both had significant effects on silent interval duration. Concerning word length, the general trend was an increase in silent interval duration, when longer words as compared to shorter ones preceded the boundary. Furthermore, silent interval duration increased, while preboundary segment duration decreased, when the NP complexity was increased. Moreover, there was a tendency to decreasing silence duration when the NP had the simplest structure, containing just a noun, and the VP increased in complexity. The same tendency was observed in the consonant preceding the boundary. This adjustment pattern, common to the silent interval and the final consonant, was assumed to occur in order to counteract imbalance in complexity between the NP and VP.

INTRODUCTION

This report extends previous work on boundary signalling and syntactic structure in Swedish. In a number of studies Swedish news texts read aloud were investigated in order to learn about the distribution of perceived boundaries and their acoustic signalling (see, for example [1]). Perceived boundaries were located in the text, and silent intervals, F₀ and temporal characteristics before and after the boundary were measured. The data revealed a close correspondence between perceived boundaries and syntax, as most of the boundaries occurred in syntactically motivated positions. The acoustic signalling of boundaries, moreover, reflected the rank of the boundary. Generally, the higher the rank, the more numerous and stronger the acoustic correlates. (Cf [2]; see also [3] for some results on the matching of prosodic boundary rank, on the one hand, and silent interval duration and preboundary lengthening, on the other.) Similar results were obtained in a study conducted by Strangert, Ejerhed and Huber [4] in which a clause structure description of a narrative text was related to three kinds of prosodic segmentation, one based on the identification of perceived boundaries and the others on F₀-resetting and silent intervals, respectively.

However, in all of these studies mismatches occurred; boundaries with a lower rank sometimes had a stronger marking than higher-rank boundaries, and there were

even cases where a high-rank boundary appeared not to have been realised at all by prosodic means. This very often happened when two syntactic boundaries occurred close to each other, which implies that constituent length exerted some influence on the distribution of prosodic boundary marking. Mismatches like these do not occur only in Swedish. Gee and Grosjean [5] discuss and attempt to explain such cases and, in line with Cooper and Paccia-Cooper [6], suggest algorithms for handling them in order to predict pausing behaviour.

The mismatch issue has relevance for the present study, which aims at exploring the influence of constituent length on a specific boundary, that between the NP and VP in a Swedish sentence material. The purpose is to account for the acoustic temporal signalling at the NP-VP boundary and, in particular, to find out the extent to which this signalling may be affected by the length of the stretch of speech preceding and following the boundary. Such effects have, for example, been studied by Terken and Collier [7] who observed a monotonously increasing silent interval duration at the NP-VP boundary in Dutch sentences, when the length of the NP was systematically increased. There were, moreover, indications that also the length of the VP had some influence on the duration of silence. (For a discussion of constituent length as a determiner of boundary marking, see also [5] and references there).

Terken and Collier [7] distinguish two factors having influence on duration structure in the vicinity of a boundary: the syntactic complexity of the stretch of speech preceding as well as following the boundary and the length of the included words. The conclusion in the Dutch study is that both factors play a role and that the effects of complexity and length is additive.

Following Terken and Collier [7], syntactic complexity as well as word length will be varied independently in the present study to learn about their respective effects on the NP-VP boundary realisation. The observations will include silent interval duration as well as segment durations of the word preceding the boundary. In particular the duration of the last vowel and the following consonant will be studied, those segments which according to studies of preboundary lengthening seem to be the most affected by an upcoming boundary (see [3] for observations on Swedish).

METHOD

The material consisted of read sentences varying in the complexity of the NP as well as the VP. The following rewrite rules demonstrate the variation:

S	→	NP VP
NP	→	(Art) (AP) N (PP)
AP	→	(Adv) A
VP	→	V NP

The word length variation was restricted to the NP. It was accomplished by having two kinds of content words, those containing 2-3 syllables, on the one hand, and 4 syllables, on the other.

By using these rules structures varying in complexity (in 5 steps for the NP and 4 steps for the VP) were generated. The different NPs (restricted to the 2- and 3-syllable content words) and VPs occurring in the experiment are listed below:

NP complexity:

1. Kvinnan
'The woman'
2. Den rika kvinnan
3. Den mycket rika kvinnan
4. Kvinnan i den lyxiga villan
5. Den mycket rika kvinnan i den lyxiga villan
'The very rich woman in the luxurious villa'

VP complexity:

1. köpte marken.
'bought the land.'
2. köpte den närliggande marken.
3. köpte marken åt sin avlägsna släkting.
4. köpte den närliggande marken åt sin avlägsna släkting.
'bought the neighbouring land for her distant relative.'

A single professional male speaker read the 40 different sentences (5 NPs x 4 VPs x 2 word lengths) 6 times each in a sound-proof chamber.

First the distribution of perceived boundaries was determined by listening to the material. The subsequent acoustic analysis was restricted to the NP-VP boundary and included measurements of silent interval duration at the boundary as well as segment durations of the word preceding it. All the segments of 'kvinnan' and 'villan', the two words occurring before the NP-VP boundary, were measured. In addition, F0 patterns before and after the boundary were examined. However, F0 characteristics will only be referred to incidentally, as they are not the principal issue here.

The duration and F0 data were obtained by measuring the digitised waveforms using ESPSwaves+.

RESULTS

Listening to the recorded material, all NP-VP boundaries were perceived as breaks in the stream of speech. Occasionally, boundaries were perceived in other positions, too. Thus, if the NP or VP contained a prepositional phrase, a boundary was very often perceived before the PP. Henceforth, however, only the NP-VP boundary will be considered. Also all acoustic measurements referred to concern this boundary.

Figure 1 shows an example of the acoustic analysis of a recorded sentence. The basis for perceiving a break at the NP-VP boundary (between 'kvinnan' and 'köpte') seems indisputable; in addition to other possible cues, there is a long silent interval as well as F0 resetting.

Silent interval duration

The mean silent duration at the NP-VP boundary for the entire material is 263 msec. However, the spread is considerable with a standard deviation of 123 msec and a range of 531 msec with extremes of 0 and 531 msec, respectively.

Varying syntactic complexity

In Figure 2 an interaction plot is given demonstrating the effects of varying NP and VP complexity. According to an analysis of variance the interaction between NP and VP is significant ($p < .01$). The following effects are distinguishable:

a) When the complexity of the NP increases, silent interval duration increases accordingly, irrespective of VP complexity. The mean difference in duration between complexity step 1 and 5 is 286 msec. Also, the main effect of NP complexity is significant ($p < .01$).

b) When the complexity of the VP increases, the silent interval duration increases between complexity step 1 on the one side and 2, 3 and 4 on the other. The mean duration difference between complexity step 1 and 2 is 60 msec.

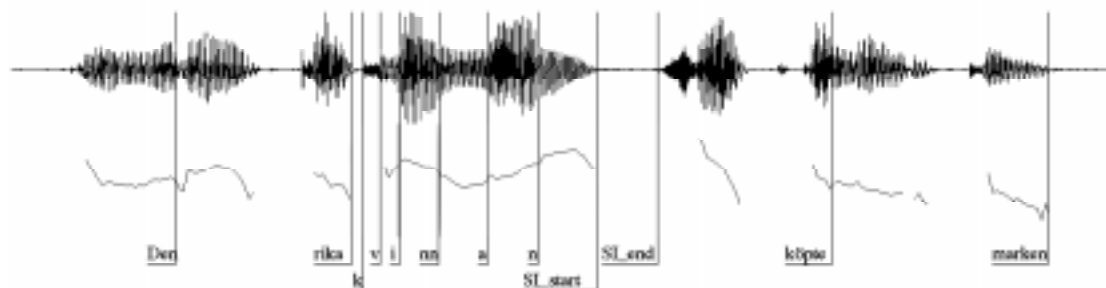


Figure 1. Acoustic analysis and segmentations of the sentence 'Den rika kvinnan köpte marken.' (The rich woman bought the land.). The labels *SI_start* and *SI_end*, respectively, mark the beginning and end of silence at the NP-VP boundary.

From step 2 to 4 the durational increase is negligible (5 msec). The main effect of VP complexity is significant ($p < .01$), although the differences between complexity step 2, 3 and 4, as might be expected, are insignificant according to post hoc testing.

c) When the NP consists of just one word (complexity step 1), then silence duration decreases upon an increase of the VP complexity. The decrease in duration amounts to 53 msec.

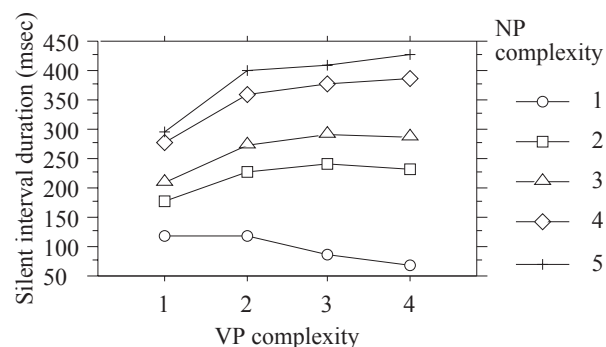


Figure 2. Interaction plot demonstrating the effects on silent interval duration of varying NP and VP complexity.

Varying word length

Word length has a significant effect ($p < .01$) on silent interval duration. The silent intervals are 68 msec longer on the average in the sentences with 4-syllable words in the NP as compared to those composed of 2 or 3 syllables. There is furthermore a significant two-way interaction between word length and NP complexity ($p < .01$). Word length and VP complexity, on the other hand, do not interact; rather they are additive.

Segment duration before the NP-VP boundary

Reporting on segment durations, the two word length categories will be treated together, that is, the data presented will be restricted to the effects of the complexity variation.

The segments of primary interest here are [a] and [n], the last vowel and the following consonant of the two words 'kvinnan' and 'villan' occurring before the NP-VP boundary. The words 'kvinnan' and 'villan' were chosen because of their structural similarity. Thus, though 'kvinnan' occurred in the sentences with NP complexity 1-3 and 'villan' occurred at complexity step 4-5, the [a] and [n] of both words will be treated together.

Both [a] and [n] durations were affected by the induced experimental variation, while the duration of the other segments remained more or less the same. Furthermore, of [a] and [n], [n] was the most affected. Mean duration for [n] was 138 msec with a range of 97 msec, while for [a] mean duration was 124 msec with a range of 48 msec.

NP and VP complexity each produced significant main effects on [n] duration ($p < .01$ for each one) and furthermore, they interacted significantly ($p < .01$). Figure 3 shows the main as well as the interaction effects. As can be seen, NP complexity variation causes strong effects on [n] duration:

a) When the complexity of the NP increases, [n] duration decreases (cf the opposite pattern for silent interval duration, increasing with increasing complexity).

b) When NP complexity is lowest (step 1), [n] decreases upon an increase of VP complexity, while there is no similarly obvious decrease when NP complexity is higher. At complexity step 1, then, the same kind of interaction occurs as for the silent interval duration (see Figure 2).

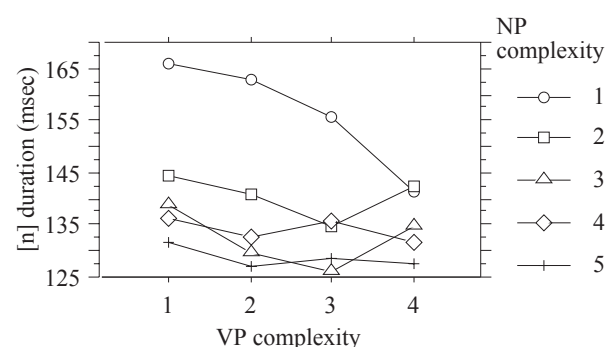


Figure 3. Interaction plot demonstrating the effects on [n] duration of varying NP and VP complexity.

As mentioned, complexity variations exert less influence on [a] duration. Only NP complexity variations give significant effects ($p > .01$). The same kind of variation as for [n] is observed, that is, [a] duration decreases upon an increase of the NP complexity. Thus [a] contribute to the compensatory pattern between the silent interval and the final part of the preceding word.

DISCUSSION

The observations clearly indicate that both syntactic complexity and word length play a role in the temporal realisation of NP-VP boundaries in Swedish sentences.

Varying NP complexity produced the greatest effects, a finding supporting that of Terken and Collier [7]. As in their Dutch study, silent interval duration increased with the complexity of the syntactic structure of the preceding NP. Increasing the VP also led to increased silence duration but to a lesser degree than for the NP. Most important, however, there was an apparent interaction pattern to the effect that, when the structure of the NP was simple (complexity step 1) silence duration decreased upon an increase of VP complexity.

It seems that this tendency to decreasing duration going against the general trend of increasing duration occurs when the complexity of NP and VP is not well balanced. An NP of complexity step 1 combined with a VP of complexity step 4 results in maximum imbalance.

Whether this is the explanation for the extremely short, and even zero silent interval durations in this condition is yet to be proven, although these findings seem indicative.

It is reasonable to link these observations to previous attempts to handle mismatches between syntax and prosody. In particular missing or weak boundary signalling in positions where such signalling would be expected on the basis of syntax seems relevant here, as mismatches of this kind occur when short constituents go together with long ones. For example, Cooper and Paccia-Cooper [6] in an algorithm for pausing, handle such cases by a specific bisection component in order to balance constituent length within an utterance.

When NP changes in complexity, the consonants immediately preceding the boundary apparently follow the opposite trend as compared to silent interval duration; [a] and [n] duration *decreases* with the growing complexity of the NP. For both segments there is a moderate negative correlation with the duration of the preceding silent interval ($r = -.59$ and $-.56$, respectively, for [a] and [n]). This compensatory pattern between preboundary segments and the silent interval is supported by similar findings in other studies (for example [7, 8]).

However, the observed interaction effects are similar to those found for silent interval duration, although they are restricted to the [n], (which generally produces stronger effects than the vowel, see also [3]). The pattern found accordingly is a decrease in [n] duration upon an increase in VP complexity in combination with NP complexity 1. Thus, the silent interval and the preceding consonant seem to adjust in a similar way to extreme differences between the NP and VP constituents.

Also word length, the second factor varied experimentally, caused significant effects. Generally, irrespective of the structural complexity, sentences with longer words gave rise to longer silent intervals than sentences composed of shorter words. Moreover, upon variation of the complexity of the VP, word length and VP complexity were truly additive.

CONCLUSIONS

The work reported on set out to investigate two factors that might influence the duration patterns at NP-VP boundaries in Swedish sentences. These factors, the syntactic complexity of the NP and VP portions of speech, respectively, as well as the length of the words in the sentence both had significant temporal effects.

Varying the syntactic complexity independently before and after the NP-VP boundary, silent intervals as well as segments immediately preceding the boundary were affected. Generally, increasing the complexity of the NP led to increased silent interval durations, while the opposite was observed for preboundary segment duration; the final consonant before the boundary decreased upon variation of the NP, leading to a

compensatory pattern between the silent interval and the preceding consonant.

In addition to this compensatory trend resulting from variation of the preceding structure, there was another tendency, common to the silent interval and the preceding consonant. When the NP had the simplest structure, containing just a noun, and the VP increased in complexity, a trend of decreasing silence and segment duration was observed. This adjustment was assumed to be a consequence of the imbalance between the structural complexity before and after the boundary in this condition.

Upon variation of the second factor, the length of the words in the NP, only the effects on silent interval duration were examined. The findings here indicate that, generally, sentences composed of longer words occurred with longer silent intervals than sentences with shorter words. Also, taking both word length and syntactic complexity into consideration, the effects of word length and complexity appeared to be additive.

ACKNOWLEDGEMENTS

Mattias Heldner is gratefully acknowledged for competent assistance and helpful criticism during the experimental stage as well as the preparation of this report. The research was supported by a grant from the Swedish HSR/NUTEK Language Technology Programme.

REFERENCES

- [1] E. Strangert, "Pauses, Syntax and Prosody", Proc. Nordic Prosody V, pp. 294-305, Turku, Finland, 1990.
- [2] A. Sanderman, "Prosodic Phrasing", Dissertation, Technische Universiteit, Eindhoven, The Netherlands, 1996.
- [3] M. Horne, E. Strangert and M. Heldner, "Prosodic Boundary Strength in Swedish: Final Lengthening and Silent Interval Duration", Proc. XIIIth International Congress of Phonetic Sciences, pp. 170-173, Stockholm, Sweden, 1995.
- [4] E. Strangert, E. Ejerhed, E. and D. Huber, "Clause Structure and Prosodic Segmentation", Proc. Seventh Swedish Phonetics Conference, pp. 81-84, Uppsala, Sweden, 1993.
- [5] J. P. Gee and F. Grosjean, "Performance Structures: A Psycholinguistic and Linguistic Appraisal", *Cognitive Psychology* Vol. 15, pp. 411-458. 1983.
- [6] W. Cooper and J. Paccia-Cooper, "Syntax and Speech", Harvard University Press, Cambridge, M. A., 1980.
- [7] J. Terken and R. Collier, "Syntactic Influences on Prosody", In *Speech Perception, Production and Linguistic Structure*, ed. by Tokhura, Y., Vatikiotis-Bateson, E. & Sagisaki, Y. IOS Press, Amsterdam, Washington, Oxford, pp. 427-438, 1992.
- [8] G. Fant and A. Kruckenberg, "Preliminaries to the study of Swedish prose reading and reading style" *STL-QPSR*, Vol. 2. KTH, Stockholm, Sweden, 1989.