Low and High, Short and Long by Crook or by Hook?

Oliver Niebuhr, Astrid Wolf

Department of General and Comparative Linguistics, University of Kiel, Germany

niebuhr@linguistik.uni-kiel.de, agl.wolf@web.de

Abstract

The paper deals with perceived speech rhythm, starting from the observation that two nouns with a conjunction in between (*'X and/or Y'*, cf. title) sound more rhythmical in a particular noun order. A perception experiment on German with real and pseudo nouns provides evidence that speech rhythm is not just created prosodically by means of high and low or long and short syllables, but that the phonetic properties of the vowel nuclei and of the consonantal onsets and offsets of the stressed syllables are separate segmental constituents of speech rhythm.

Index Terms: speech rhythm, segments, word order, German.

1. Introduction

Of all functionally relevant phenomena in spoken communication, rhythm has one of the longest research traditions, but it is at the same time still one of the least well understood phenomena. There are three main issues that make the study of speech rhythm a particular challenge.

(1): Our perspective on the signal-internal phonetic constituents of speech rhythm is still too narrow. For example, the investigation of rhythm was for a long time dominated by measuring durations of segmental and suprasegmental (e.g., syllabic) phonetic and phonological units [1,2]. Studies on speech rhythm have just started to go beyond duration and to include other prosodic parameters like F0 and intensity [3,4]. This new, multiparametric perspective was facilitated by the workshop on "Empirical Approaches to Speech Rhythm" that was held at the University College London in 2008.

(2): While initial studies tried to assess speech rhythm in terms of absolute phonetic measurements (e.g., syllable or foot durations) it is common understanding now that speech rhythm is essentially a relational phenomenon [4,5]. However, it is still far from being settled what the relevant units in these relations are [2]. Moreover, it is likely that the relevant units differ from language to language, even though the speech rhythms may be more similar across languages than it was originally expected [6].

(3): Speech rhythm is ultimately a perceptual phenomenon; and we still underestimate the spectrum and power of cognitive – i.e. signal-external – contributions to speech rhythm. For example, there is empirical evidence that the rhythmmic context as well as both lexical and intonational semantics can generate expectations that override even strong following or preceding prosodic cues to speech rhythm in the signal [7,8]. Moreover, it was indirectly shown that speech rhythm is affected by the listeners' knowledge about syntactic and semantic structures and their statistical frequencies [9,10,11], and that utterances sound more rhythmical with sequences of the same than with sequences of different pitch accents [8].

In the recent paper [4] of Kohler an attempt is made to integrate the points above by defining speech rhythm as waning and waxing prominence profiles that occur with some degree of regularity across syllable chains. The prominence profiles are constituted by changes in the prosodic parameters F0, duration and acoustic energy. Along with his definition, Kohler emphasizes the importance of a regular rhythm for speech perception. Speech rhythm is not only determined by syntactic and semantic patterns, but it can also shape these patterns. In noun phrases like *'X and Y'* monosyllabic nouns are more likely to be 'X' and disyllabic nouns (with initial lexical stress) are more likely to be 'Y' (unless contextual factors or social conventions require a different order, [4]). The resulting alternation of stressed and unstressed syllables and the F0, duration, and acoustic energy changes they entail create a recurring waxing-waning prominence profile for the listener. For example, depending on which words are monosyllabic or disyllabic we have *bow and arrow*, *peace and quiet* and *hen and chicken* in English, but *Pfeil und Bogen* (arrow and bow), *Ruh(e) und Frieden* (quiet and peace) and *Huhn und Henne* (chicken and hen) in German.

However, there are a number *'X and Y'* phrases that consist of nouns with identical numbers of syllables and that hence create equally waxing-waning prominence patterns in either noun order. Yet, these phrases still show a clear noun-order preference, which cannot be covered by Kohler's purely prosodic and prominence-related definition of speech rhythm. Oakeshott-Taylor ([12]) dealt with such phrases like *tit for tat, up and down, good and bad.* The phrases *high and low*, *long and short* as well as *by hook or by crook* also belong to this class of phrases. In the reverted order given in the title of this paper they sound bumpy to many listeners. Using stimuli that consisted of stressed CVC pseudo words conjoined by unstressed *and*, the perception experiments in [12] showed that the preferred order of the monosyllabic pseudo words was highly correlated with their vowel qualities. Those stimuli sounded better, for which the vowel in the second CVC syllable was more open and/or longer than in the first CVC syllable (e.g., *CuC and Ca:C* sounded better than *Ca:C and CuC*). Similar results were found for Afrikaans and German.

Oakeshott-Taylor emphasizes that further research is needed to isolate the effects of consonants on word-order preference. This concluding statement represents the starting point of our study. Our aim is to show by means of perceptual judgments on the rhythm of both real and pseudo noun sequences that there is more to the acoustic properties of speech rhythm than just duration, F0 and acoustic energy changes. The acoustic properties of local speech segments in stressed syllables do also contribute to speech rhythm, and this contribution goes beyond the vowel in the syllable nucleus and includes the consonants in the syllable onset and coda.

Our study focuses on German and is based on *'X and Y'* phrases with disyllabic nouns. The disyllables we used show initial lexical stress and hence waxing-waning prominence patterns as, for example, in *Oma und Opa* (grandma and grandpa), *Bruder und Schwester* (brother and sister), *Onkel und Tante* (uncle and aunt), *Messer und Gabel* (knife and fork), *Arme und Beine* (arms and legs), *Nadel und Faden* (needle and thread), *Biegen und Brechen* (by hook or by crook), *Lachen und Weinen* (laughing and crying), *Höhen und Tiefen* (highs and lows), *Heller und Pfenning* (two currencies),

Hanni und Nanni (two names). These 11 phrases represent the first half of 22 common real-word noun phrases (cf. [13] for the full list) that are used as basic condition in our experiment, cf. hypothesis (I) below. Moreover, by analyzing the segmental structures of the stressed syllables in the 22 disyllable pairs, we developed our main hypotheses (IIa-e).

Hypothesis (I) addresses the 22 real-word noun phrases: The phrases sound more rhythmical in the naturally occurring order than in the inverse order.

Hypotheses (IIa-e) were tested by means of two disyllabic pseudo nouns (each with initial stress and waxing-waning prominence pattern) conjoined by unstressed *und* (and).

(IIa): The results of [12] will be replicated. The phrases sound more rhythmical when the vowel in the initial stressed syllable of the second noun is more open and longer than in the stressed syllable of the first noun.

(IIb): The phrases sound more rhythmical when the initial stressed syllables of the first and second noun have sonorant and obstruent onsets rather than obstruent and sonorant onsets.

(IIc): However, [h] is an exception within the onset consonants. Irrespective of the type of onset consonant of the second noun, the phrases sound more rhythmical when the first noun starts with [h].

(IId): The phrases sound more rhythmical when the initial stressed syllables of the first and second noun have sonorant and obstruent codas rather than obstruent and sonorant codas.

(IIe): The phrases sound more rhythmical when the initial stressed syllables of the first and second noun have obstruent and empty codas rather than empty and obstruent codas.

2. Method

In order to avoid any influence of word meanings or collocation frequencies on the subjects' judgments, it was necessary to base the main experimental stimuli of hypotheses (IIa-e) on sets of pseudo-noun phrases. Three such sets were created. In each set the syntagmatically contrasting consonant and vowel conditions were to show very clear phonetic differences. So, with regard to hypothesis (IIb) the contrasting syllable-onset conditions were the single voiced sonorant [l] and the voiceless obstruent cluster [kʁ̥]. Two similar conditions were created in the syllable coda by means of the single voiced sonorant [n] or [m] and the voiceless obstruent cluster [pf] (cf. hypothesis IId). A third and empty-coda condition ∅ was added in order to account for hypothesis (IIe). The onset and coda consonants framed the constant, open and phonologically long vowel nucleus [a:]. In cross-combination the 2 onset x 3 coda consonant conditions formed 12 stressed C(C)-[a:]-C(C) syllables, to which the constant syllable *–ten* ([tʰɪ̯n], the most frequent unstressed syllable in German) was attached. In this way, 12 disyllabic pseudo nouns with waxing-waning prominence patterns (based on stressed-unstressed syllables) were created. Conjoined by *und* (and) in all possible different combinations and orders, a total of 30 noun phrases resulted that will be referred to as the 'first onset-coda set' (e.g., *Lahn-ten und Krahn-ten, Laapf-ten und Kraapf-ten;* stressed-syllable template: {l| kʁ̥} a: {n/m|pf|∅}) .

The other two pseudo-noun sets were both derived from the first onset-coda set. In the 'vowel set' the 2x3 consonants in the onsets and codas of the stressed syllables were the same as in the first onset-coda set. However, they did not only frame the open long vowel [a:], but also the close or mid short vowel [ʊ] or [ɔ]. The two syntagmatically contrasting vowel conditions aimed at hypothesis (IIa, cf. [12]) and were again clearly different in terms of duration and intrinsic sonority. Conjoining all pairs of different pseudo nouns by *und* in both possible orders yielded a total of 36 phrases for the vowel set (e.g., *Laapf-ten und Lopf-ten, Krupf-ten und Lahn-ten*). In order to address hypothesis (IIc) the experiment included another set of test phrases that was identical to first onset-coda set, except that the onset condition [kʁ̥] was replaced by [h]. So, the syntagmatically contrasting stressed-syllable onsets were [h] and [l]. The resulting 30 pseudo-noun phrases will be referred to as the 'second onset-coda set' (e.g., *Lahn-ten und Hahn-ten, Haapf-ten und Laapf-ten*). The 96 pseudo-noun phrases of all three sets were complemented by a fourth set of the 44 real-noun phrases (cf. introduction), i.e. 22 phrases in both naturally occurring and inverse orders.

The 96+44=140 real-noun and pseudo-noun phrases were recorded (cf. [13]) in a sound-treated room at the Institute of Phonetics, Kiel. They were produced by a trained phonetician. The speaking rate was held constant. The disyllables were realized with equally waxing-waning prominence patterns, resulting from clear stress and H* pitch accents on the two initial syllables (the second H* downstepped). The conjunction *und* was produced in an unstressed and slightly reduced fashion.

In the experiment the three sets of phrases were presented in separate sessions with pauses of about 5 min between them in order to make the task for the subjects less demanding and tiring. The phrases within each session were randomized. The experiment was done with 51 native speakers of German (25 male, 26 female, 17-23 years old) that were split up into two groups of 28 and 23 subjects. The groups started with either the vowel set or an onset-coda set. The set of real-noun phrases was always judged in the last of the three sessions to rule out these phrases can cause any learning or anchor effects in the main pseudo-noun test sets. Moreover, group 1 judged only the first and group 2 only the second onset-coda set. In this way, the experiment was shortened by 30 judgments (140-30=110). The phrases were presented in silent rooms over high-end loudspeakers. Each phrase was presented twice, separated by 1 sec. The phrase pairs were preceded by a bleep and followed by a pause of 4 sec, during which the judgments were made. The subjects were instructed that they would hear noun phrases of the type *'X and Y'* consisting of either real or pseudo nouns. Their task would be to listen carefully to each pair of phrases and to judge afterwards as spontaneously as possible, how rhythmic the phrase sounded, using a 6-point scale from 'very weakly rhythmic' / "bumpy"' (=1) to 'very strongly rhythmic' / "fluent"' (=6). Judgments were made on prepared answer sheets that provided for each phrase (pair) its chronological number in the experimental session and the corresponding 6-point scale. That is, orthographical representations of the phrases were *not* shown to the subjects.

3. Results

At first, it must be noted that t tests on rhythm scores found no significant differences between the judgment behaviour of musical and non-musical or male and female subjects within groups 1 and 2. Thus, judgment data were pooled across subjects for our variables noun order and syllable structure.

The real-noun phrases were judged by all 51 subjects of groups 1 and 2 in naturally occurring and inverse orders. So, a total of 2.244 judgments were made across all presentations. For an initial descriptive analysis, the rhythm scores of the individual phrases on the scale from 1-6 were summed up for each of the two noun orders across all subjects. Figure 1 displays on this basis in terms of means that, overall, the naturally occurring order was clearly preferred over the inverse order. A more detailed picture of the results was provided by an additional repeated-measures ANOVA with noun order and phrase

as within-subjects variables. The rhythm scores served as dependent variable. The ANOVA yielded significant main effects of both noun order ($F_{[1,50]}$=948.33; p< 0.001; η^2_p=0.92) and phrase ($F_{[21,1050]}$= 299.68; p<0.001; η^2_p=0.41), but no significant interaction between them. The noun-order effect was much stronger in terms of effect size (η^2_p) than the phrase effect. However, the phrase effect indicates that the naturally occurring order was not as clearly preferred across all phrases as Figure 1 may suggest. Seven of the 22 phrases yielded slightly less distinct rhythm scores in the two noun orders. Closer inspections of these phrases and informal interviews with subjects after the experiment point to two main reasons for the judgment differences between the phrases. The phrases whose naturally occurring noun order was less clearly preferred either triggered different visuospatial associations (e.g., *Hammer und Sichel*), or they were linked with social conventions like gender roles (e.g., *Mama und Papa* 'mum and dad', *Männer und Frauen* 'men and women').

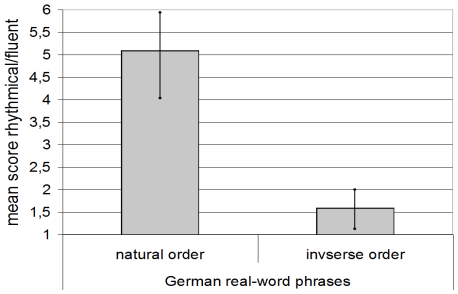

Figure 1: *Mean rhythm scores for the real-noun phrases presented in naturally occurring and inverse orders and judged by 51 sbs. (each bar = 1.122 judgments).*

The most important descriptive findings for the pseudo-noun phrases are summarized in Figures 2-3. Figure 2 presents the results of the 30 phrases of the first onset-coda set that was judged by the 28 subjects of group 1. It shows in terms of mean scores across all subjects how rhythmical the phrases were perceived when they started with each of the 6 different pseudo nouns. Correspondingly, Figure 2 represents a total of 840 judgments, 140 per noun. As can be seen, the distribution of percentages across the 6 pseudo nouns is strikingly straightforward. Phrases were more rhythmical when the first noun had a voiced sonorant [l] and the second a voiceless obstruent cluster [kʁ̥] in the onset of the stressed syllable. That is, *L__-ten und Kr__-ten* phrases were preferred over *Kr__-ten und L__-ten* phrases. Then, within each of the two onset conditions the rhythm of the phrases was also better when the first noun differed from the second in having a voiced coda ([n]) instead of a voiceless coda ([pf]) in the stressed syllable. However, both voiced and voiceless codas sounded more rhythmical than empty codas in the stressed syllable of the first noun. For example, *Lahn-ten und La-ten* as well as *Laapf-ten und La-ten* were preferred over *La-ten und La{hn/pf}-ten*.

The descriptive analysis is supported by a repeated-measures ANOVA with syllable onset and syllable coda as independent within-subjects variables and the rhythm scores as dependent variable. The phonetic properties of both onset and coda consonants yielded highly significant main effects (onset: $F_{[1,27]}$=112.05; p<0.001; η^2_p= 0.70; offset: $F_{[2,54]}$=167.44; p<0.001; η^2_p=0.59). In addition, the main effects interacted significantly ($F_{[1,27]}$=56.13; p<0.001; η^2_p=0.37). However, as is indicated by η^2_p the explanatory power of this interaction is relatively low compared with the two main effects. The interaction is primarily due to the fact that the coda effect was smaller with the [kʁ̥] onset than with the [l] onset (cf. Fig.2).

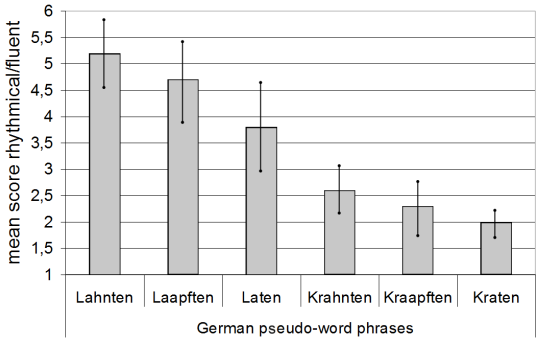

Figure 2: *Mean rhythm scores for the 30 pseudo-noun phrases of the first onset-coda set. n=840;140 judgm. per bar. Each bar refers to all 5 phrases that start with the noun shown below the bar, followed by each of the other 5 nouns.*

The 30 phrases of the second onset-coda set were judged by the 23 subjects of group 2. In terms of the three coda conditions (i.e. voiced [n], voiceless [pf], and empty coda) the results of the second onset-coda set parallel the results of the first set. Within each onset condition ([l] or [h]) phrases were more rhythmical when the first and the second noun show a voiced and a voiceless or a voiceless and an empty coda in the stressed syllables (Fig.2). The replication of the coda effect by a different group of subjects supports its robustness. However, different from the first onset-coda set, the 30 phrases of the second set did not sound more rhythmical when the first noun started with a voiced and the second with a voiceless onset. Rather, the rhythm of the phrases was better with voiceless [h] in the onset of the first and voiced [l] in the onset of the second noun. So, *H__-ten und L__-tan* was consistently preferred over *L__-ten und H__-ten*. This clear onset effect is shown in Figure 3(a). Each bar summarizes 345 judgments.

Overall, from the perspective of the first noun (combined with all other nouns) the rhythm scores of the phrases decreased in the order *Hahn-ten* > *Haapf-ten* > *Ha-ten* > *Lahn-ten* > *Laapf-ten* > *La-ten* > *Krahn-ten* > *Kraapf-ten* > *Kra-ten*.

The results of repeated-measures ANOVA done for the second onset-coda set resemble the results of the first set. The two main effects of syllable onset and syllable coda were both highly significant (onset: $F_{[1,22]}$=87.92; p< 0.001; η^2_p=0.77; offset: $F_{[2,44]}$=61.34; p<0.001; η^2_p=0.54). In addition, there was a significant interaction between onset and coda effect, but with a low effect size ($F_{[1,22]}$=45.22; p<0.001; η^2_p=0.28).

Like the 22 real-noun phrases, the 36 pseudo-noun phrases of the vowel set were judged by all 51 subjects of groups 1 and 2. The phrases of the vowel set were constituted by the same two onset and three coda conditions as the first onset-coda set, supplemented by a syntagmatic contrast between the open long vowel [a:] and a closer short vowel [ʊ] or [ɔ] in the initial stressed syllables of the two pseudo nouns. As is shown in Figure 3(b) (each bar=918 judgments) the rhythm of the phrases was strongly affected by vowel order. Almost all phrases, i.e. largely independent of the their onset and coda consonants, yielded higher rhythm scores when the vowels in the strong syllables of the two pseudo nouns occurred in the order close+short–open+long ([ʊ]/[ɔ]-[a:]) rather than in order open+long–close+short ([a:]-[ʊ]/[ɔ]). For example, *Lopf-ten und Laapf-ten, Krupf-ten und Kraapf-ten,* and even *Krupf-ten und Lahn-ten* sounded more rhythmical than *Laapf-ten und Lopft-en, Kraapf-ten und Krupf-ten, Lahn-ten und Krupf-ten*.

The corresponding three-way repeated-measures ANOVA was also dominated by the additional within-subjects variable vowel order. While the [ʊ]/[ɔ]–[a:] vs. [a:]–[ʊ]/[ɔ] vowel se-

quences had a highly significant effect that was on its own able to explain almost all variance in the judgment data ($F_{[1,100]}$=356.86; p<0.001; η^2_p=0.94), the effect of the syllable onset ([l] vs. [kʂ]) was still significant, but less important ($F_{[1,100]}$=90.67; p<0.01; η^2_p=0.40), also in relation to the results of the first onset-coda set. Moreover, the onset effect interacted significantly with the vowel-order effect ($F_{[1,100]}$= 47.11; p<0.01; η^2_p=0.19). This is due to the fact that the influence of the [l] vs. [kʂ] difference on judgments was largely restricted to the [ʊ]/[ɔ]–[a:] vowel order. Finally, the significant coda effect that was found for the phrases of the two onset-coda sets disappeared in the phrases of the vowel set.

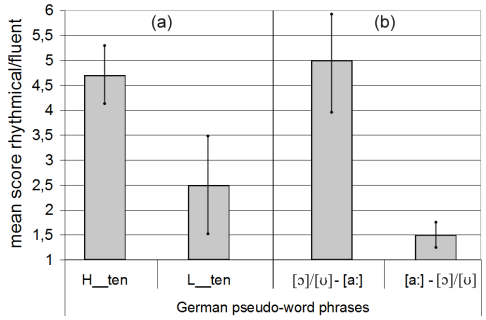

Figure 3: *Mean rhythm scores: (a) for the 30 phrases of the second onset-coda set starting with either [h] or [l] in the first noun (n=690; 345 judgm. per bar); (b) for the 36 phrases of the vowel set. The strong-syllable vowels in this set change from the first to the second noun either in the direction* [ʊ]/[ɔ]–[a:] *(left bar, n=918) or* [a:]–[ʊ]/[ɔ] *(right bar, n=918).*

4. Conclusions

All our hypotheses have been confirmed by the perception experiment. Within a constant prominence pattern (based on a succession of stressed and unstressed syllables), rhythm judgments are systematically affected by the segmental make-up of the initial stressed syllables of disyllabic nouns in *'X and Y'* phrases. As regards the effect of the vowel nuclei, our study replicated the findings of [12]. The *'X and Y'* phrases sounded more rhythmical when the vowel in the stressed syllable of the second noun (Y) was longer and more open than in the first noun (X), i.e. first [ʊ] or [ɔ], then [a:]. However, leading on from [12] the rhythmical influence of segmental properties also involved the onset and coda consonants of the stressed syllables: *'X and Y'* phrases sounded more rhythmical when (a) the first noun (X) began with [h] or when (b) the first noun (X) began with a voiced sonorant and the second (Y) with a voiceless obstruent cluster. As for the syllable codas, a higher rhythm score was achieved when the stressed syllables of the first and second nouns ended in (a) voiced (X) and voiceless (Y) consonants or (b) in filled (X) and empty (Y) codas. Moreover, our data suggest the following hierarchy of the segmental effects on speech rhythm: nucleus > onset > coda. Interestingly, this order matches well with the average sonority of the three syllable elements in German and other languages.

Since the segmental effects on preferred word order in [12] were similar across different (Western-Germanic) languages, we also expect that our findings have a cross-linguistic relevance. Moreover, the fact that the vowel and consonant effects showed up in different experiments with different groups of subjects underlines the robustness of the segmental contributions to speech rhythm. The lack of a coda effect in the phrases of the vowel set could be an artefact of the ambisyllabicity that resulted when a short vowel was followed by an empty coda (e.g., *Laten* or *Krutten)*. Accordingly, our findings can explain a lot of preferred noun orders in naturally occurring *'X and Y'* phrases, including the German phrases in the introduction. Likewise, as regards the English phrases in the title of this paper, it matches with our conclusions that *by hook or by crook* is preferred over *by crook or by hook* and that *high and low, long and short* occur more frequently in speech corpora than *low and high, short and long*. However, the results of our real-word noun phrases also demonstrated why not all *'X and Y'* phrases with the same number of syllables comply with our conclusions. Creating a regular/fluent speech rhythm always competes in speech production and perception with semantic and syntactic requirements or social/cultural norms and their resulting frequencies of word orders, cf. [4].

As for the issues (1)-(3) raised in the introduction, our study shows that speech rhythm is neither just prosody (F0, duration, intensity) nor can it be just prominence that creates perceptually successions of more salient and more subtle syllables (i.e. feet). Thus, even the recent multiparametric definition of rhythm by [4] falls short of representing all aspects of the overall phenomenon. From this point of view, our paper opens a new field in the research of speech rhythm. Follow-up studies must address further languages, both stressed and unstressed syllables, and more classes/properties of segments. Moreover, the follow-up studies will benefit from a conceptual distinction between rhythm and rhythmicity. For example, the repetition of a particular foot, created by means of prosodic prominence, results in a particular *type of rhythm* (iambus, dactyl etc.). Then, *within* each type of rhythm, other segmental and suprasegmental properties as well as their repetition lead to different *degrees of rhythmicity*.

5. References

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