THE DOMAIN OF ARTICULATION RATE VARIABILITY IN CZECH

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ABSTRACT

An experiment using three samples of spontaneous Czech speech from different speakers was conducted to find out whether variability of articulation rate (AR) is bound to a certain domain. AR was examined within three candidate units: the interpause stretch, the tone unit and the clause. In none of these units is AR constant. However, the tone unit manifests a regular pattern (a gradual slowing down) of AR.

1. INTRODUCTION

Articulation rate, i.e. a measure of rate of speaking in which pauses are excluded from the calculation, has not been widely studied. Taking into consideration only research on intra-speaker AR variability, several studies show that there is a considerable variability throughout the speech of an individual (e.g. [1], [2]). Unfortunately, due to differences in methodology (varying minimum pause duration, measures of rate used and, in particular, the unit across which AR is measured), the results across different studies are not readily comparable. A few other studies go beyond the quantification of AR variability by examining what are its determinants. Crystal & House ([3]), for instance, claim that the AR of a stretch of speech depends on its phonological structure. Eefting ([4]) states that intentions of the speaker with respect to the listener play an important role. Kaiki *et al.* ([5]) also point out the relevance of the difference between content and function words.

It should be noted, however, that an explicit justification for the choice of the unit across which AR is measured is often missing. As Eefting ([4]) notes, this may imply that AR within such a unit is assumed to remain constant. Lack of clarity in this matter indicates that articulation rate is a phenomenon whose functioning is still far from well understood and that it is not obvious how to incorporate it into linguistic theory.

This paper aims to investigate one aspect of AR variability by asking whether AR is indeed constant within some unit of speech or whether it follows some regular pattern; in other words, whether there is a fixed domain of AR variability.

2. METHOD

Three candidate units were chosen, within each of which AR was measured: the interpause stretch, the tone unit and the clause. The reasons for this choice were the following. In the case of the interpause stretch (for which the minimum criterial pause duration was 130 ms), pause characteristics and AR are known to be related (e.g. [6]). Moreover, this is the unit most often used in past research on AR variability. Tone units (defined as in [7]) are considered to be units of both rhythm and intonation in Czech ([8]), these being related notions. Clauses (syntactic stretches containing a finite verb) were chosen to cover the possibility of syntactic determination of AR variability. The minimum unit across which measurements were carried out was the phonological word, defined as a string of syllables with one stress. Within phonological words (henceforth simply 'words') AR was expressed as the number of syllables per second.

Three samples of Czech speech from three native speakers (one male and two female) were used; these were students of Charles University, Prague, aged 22 - 25 years. All samples were two minutes long and consisted of unprepared monologue on a topic chosen by the speaker. A picture from a children's book was available as a catalyst in case the subject did not know what to talk about.

The measurements were carried out with Signalyze™ 2.03 speech processing software using the time-amplitude and spectrograph displays.

3. RESULTS

Since the initial impressionistic analysis suggested that AR variability might in some way be bound to tone units, these were examined first.

The total number of tone units analysed was 179, out of which the majority were one word long (30.5%). In general, the more words tone units contained, the fewer there were of them (2-words TU: 22%; 3-words TU: 24%; 4-words TU: 14%; 5-words TU: 8% and 6-words TU: 1.5%).

3.1 Is articulation rate constant within tone units?

Comparison of the AR of the phonological words in 2-word tone units showed that these words were generally markedly dissimilar. In 85% out of the total of 39 tone units, the second word was slower than the first one.

For 3-, 4- and 5-word tone units, the coefficient of variation (i.e. deviation from the mean expressed as a percentage) was calculated. The values for all these tone units together a⁻ shown in the figure below.
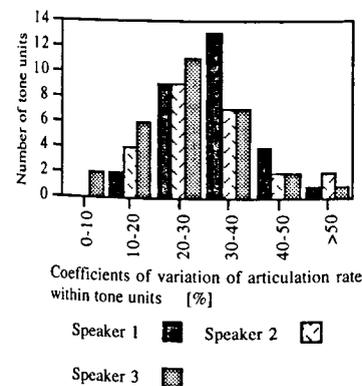
Figure 1. Frequency distribution of tone units according to their internal AR variability

Figure 1. shows that AR variability within tone units is far from constant. Variability is typically between 20% and 40%. Values below 10% and above 50% can be described as exceptional. A similar analysis was conducted separately for groups of tone units sharing the same number of words; this showed that the same range of variability holds for all groups. Such a high degree of variability is unlikely to be due solely to phrase-final lengthening; it must be distributed throughout the whole tone unit.

3.2 Internal structure of AR variability within tone units

This part of the analysis focussed on tone units consisting of 2, 3, 4 and 5 phonological words. The analysis was based on the rank ordering of component words according to their AR. Absolute values of AR were not considered at this stage.

As observed above, in the absolute majority (85%) of 2-word tone units the second phonological word was slower than the first one. Taking together tone units larger than this, in 88% of the cases, the first or the second word was the fastest. The number of tone units in which the first word was the fastest was approximately equal to the number in which the second word was the fastest. The last word tended to be the slowest; only exceptionally was it the fastest word in a tone unit.

Apart from these tendencies, other regularities occurred in all three speech samples. In particular, the majority of tone units shared a similar pattern of AR variability - a gradual decrease throughout the unit. I shall refer to it further as 'rallentando'.

For 3-word tone units, the prevailing patterns, represented iconically, are given in Table 1. (dots stand for phonological words, lines for the direction of AR change; the distance between the dots does not reflect the actual differences in AR; the percentage shows how many tone units of a certain pattern occurred in the total number of tone units of the same size):

Table 1. Prevailing patterns of 3-word tone units

For 4-word tone units, six patterns were classified as rallentando, using the following diagnostic test: (i) the phonological word with the highest AR must be in the first or the second position within the tone unit; (ii) the phonological word with the slowest AR must not follow immediately that with the highest, and (iii) there must be no more than one increase in AR between successive phonological

words within the tone unit. The relevant patterns are shown in Table 2.

Table 2. Prevailing patterns of 4-word tone units

C (24%)	D (20%)	E (8%)
F (8%)	G (4%)	H (4%)

In total, the percentage of tone units with a rallentando pattern was 68%.

For 5-word tone units, the same rules defining rallentando patterns applied. This pattern occurred in 50% of cases.

This analysis leads to the conclusion that AR does vary within tone units and that the variability is systematic in the majority of cases - it gradually decreases. In the group of patterns that were not classified as rallentando, a few cases showed a gradual increase in AR within the tone unit (an 'accelerando' pattern) and the others did not form a homogeneous group and were called 'anomalous'.

In summary, the tone unit is a plausible candidate for the domain of AR variability.

3.3 The relation between the 'size' of the phonological word and its AR

At the next stage of the analysis, the possibility of explaining anomalous and accelerando pattern in terms of the size of component phonological words was considered. By (phonological) size is meant the number of syllables and long vowels in the word. Czech has distinctive vowel quantity and long vowels are claimed to be about twice of the duration of their short counterparts, thus a word with e.g. 3 syllables and no long vowel (3 /0/) is taken as equivalent to a word with 2 syllables and 1 long vowel (2 /1/).

The analysis did not demonstrate any consistent correlation between the size of component words of the tone units and their AR. Some typical examples are shown in Table 3. (AR is in syll/s).

Table 3. The relationship between the phonological size of words and their AR

	2 /1/ 5.00	4 /0/ 7.51	4 /0/ 5.73	
	3 /1/ 7.40	3 /1/ 5.25	2 /0/ 8.03	2 /0/ 5.52
	4 /1/ 7.19	2 /0/ 6.60	3 /0/ 9.06	2 /0/ 3.75

Phonological words of the same size differ in their AR considerably. There is also no consistent tendency for the smallest words to be the slowest and the largest words to be the fastest and vice versa. The patterns in Table 3. were all classified as anomalous but the analysis showed similar results for rallentando patterns too. Thus, the position of a word within a tone unit seems to be more important for the AR than the word's size.

An additional examination of anomalous and accelerando patterns in terms of their linguistic structure and pausing suggests that there might be some link between the kind of a word (functional vs. content), the character of a planning process (hesitations), etc. These speculations will, however, have to be examined in more detail in the future.

3.4 Structure of AR within interpause stretches and clauses

The first part of the analysis suggested that the tone unit is a plausible candidate for the domain of AR variability. In the second part, AR within interpause stretches and syntactic clauses was examined since these units may covary with tone units or demonstrate different systematic patterning.

3.4.1 Interpause stretches

The total number of interpause stretches in the material was 119. In all three speech samples, interpause stretches were coextensive to a considerable extent with tone units (80%, 58% and 59% for speakers 1, 2 and 3 respectively). Boundaries even of those interpause stretches in which this was not the case coincided with tone unit boundaries. They contained up to three tone units. Close examination of all interpause stretches failed to reveal any consistent regular patterning which would involve the interpause stretch as a whole. The only patterning observable was patterning within tone

units. An illustration of this can be seen in Figure 2. below (points represent the AR of individual successive phonological words; successive points/words of the same colour - black or white - belong to the same tone unit; vertical lines indicate boundaries of interpause stretches).

Phonological words 110-168
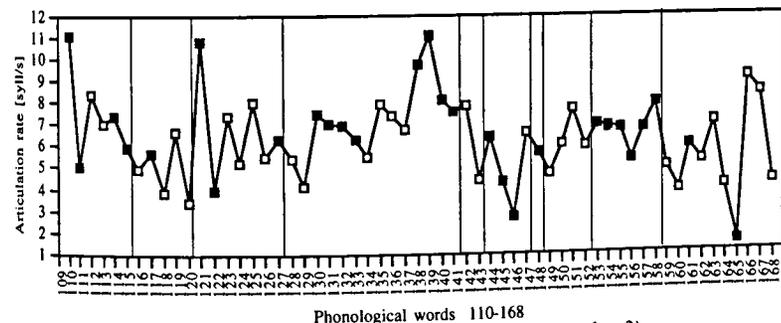
Figure 2. Interpause stretches containing words 110 - 168   (speaker 3)

3.4.2 Syntactic clauses

General findings in the analysis of clauses were similar to those for interpause stretches. Coincidence of clauses with single tone units was relatively high (69%, 52% and 55% for speakers 1, 2 and 3 respectively). In clauses which contained more than one tone unit (the boundaries normally coincided), no systematic patterning of AR variability was found. Again, the only patterning detected was that within tone units.

4. CONCLUSION & DISCUSSION

The pilot experiment described suggests that AR does have a domain of variability - the tone unit. Contrary to the implications in the literature (see above), there does not seem to be any level at which AR is constant if we accept that the phonological word is the minimum measurement unit in which it is reasonable to talk about 'articulation rate'. There is, however, a recurrent pattern of variability within the tone unit - a gradual slowing down with the first or the second word being the fastest. These regularities do not correlate with the number of syllables and long vowels in component words.

Neither the interpause stretch nor the clause demonstrate any systematic intra-unit AR patterning.

The results are in agreement with the claims about the importance of the tone

unit with respect to speech rhythm. Also, they suggest that the tone unit might be a planning unit at some stage of speech processing. A larger-scale analysis will be conducted in the future to test the results in Czech and also English.

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