

## NOTES ON SYLLABLE DURATION IN FRENCH AND SWEDISH

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## ABSTRACT

We have studied the durational contrast of stressed and unstressed syllables as a function of the number of phonemes per syllable. Observed differences in regression lines for the French and the Swedish data are discussed with respect to the concepts of syllable timing and stress timing. We have also studied the effect of tempo in French. A noteworthy observation is the constancy of pre-pause syllable durations with tempo variations.

## INTRODUCTION

In our earlier study [1] comparing the reading of a one minute long passage from a Swedish novel which was translated into English and French, we measured average syllable durations within a stressed/unstressed, i.e. an accented/unaccented, labelling and as a function of the number of phonemes per syllable. The smaller durational contrasts between stressed and unstressed syllables in French than in Swedish and English gave a support for the established notion of French as a syllable timed language and Swedish and English as stress timed languages. The concept of "stress timing" is attributed not to a physical isochrony but to an overall relative greater auditory prominence of the alternation between stressed and unstressed syllables.

The present study provides data on the same text for one more French subject and variations of reading speed and it provides a more detailed comparison of Swedish and French data. For details about the text see [1]. A perceptual binary labelling of syllables as stressed and unstressed performed by three trained listeners revealed that in all three languages about 90 % of the stresses were found in content words including adverbs. Comparing syllables of the same number of phonemes we found about 50 ms stressed/unstressed contrast in French and about 120 ms in Swedish. The average number of

phonemes per unstressed syllable was 2.1 in French and 2.25 in Swedish, while stressed syllables showed a marked difference, 3.0 in Swedish and 2.3 in French, which contributes to the overall greater durational contrast in Swedish. In the present study we have investigated to what extent the particular dominance of phonemes of inherently long duration should be taken into account when comparing stressed and unstressed syllables. We have also made a more detailed analysis of pre-pause terminal stress in French versus the "minor stresses" within a phrase and in relation to speech tempo.

## SWEDISH REFERENCE DATA

Figure 1 illustrates average syllable duration as a function of the number of

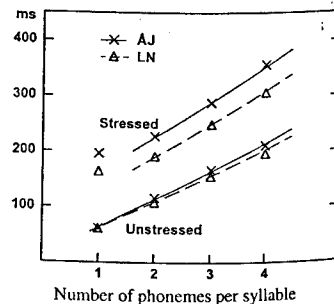
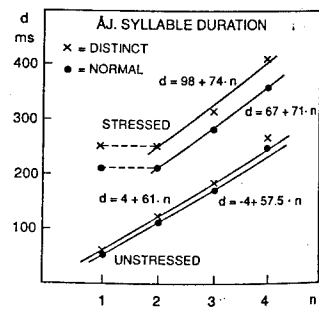


Figure 1. Syllable duration from Swedish prose reading.

phonemes in stressed and unstressed syllables of the original Swedish prose text. The two speakers in the lower graph differ significantly in the duration of stressed syllables but marginally only in terms of unstressed syllables.

A quite similar relation is to be seen in the upper graph which is a comparison of our reference subject AJ reading the text twice, in a distinct mode and in a normal mode. There is an apparent stability of the duration of unstressed syllables whereas the stressed/unstressed contrast is a speaker and speaking specific feature. In 2-phoneme syllables the stressed/unstressed difference was 98 ms and 112 ms in 3-phoneme syllables. In the distinct reading mode the contrast was 25 ms greater than in the normal speaking mode. Unstressed syllables

averaged 125 ms and stressed syllables 290 ms.

## A COMPARISON OF FRENCH AND SWEDISH

A typical French prosodic phrase is illustrated in Figure 2, "Le long de trois des murs...". The intonation contour here marks three so called prosodic words, i.e. three "stress groups", each containing a content word with an  $F_0$  rise of the order of 6 semitones in the vowel, in non-final groups followed by a corresponding  $F_0$  fall. The recurrent pattern of  $F_0$  rises and falls in successive prosodic words within a phrase and the associated lengthening of stress-group final syllables produces a rhythmical regularity. The large duration of the phrase-final syllable [my:r] is apparent.

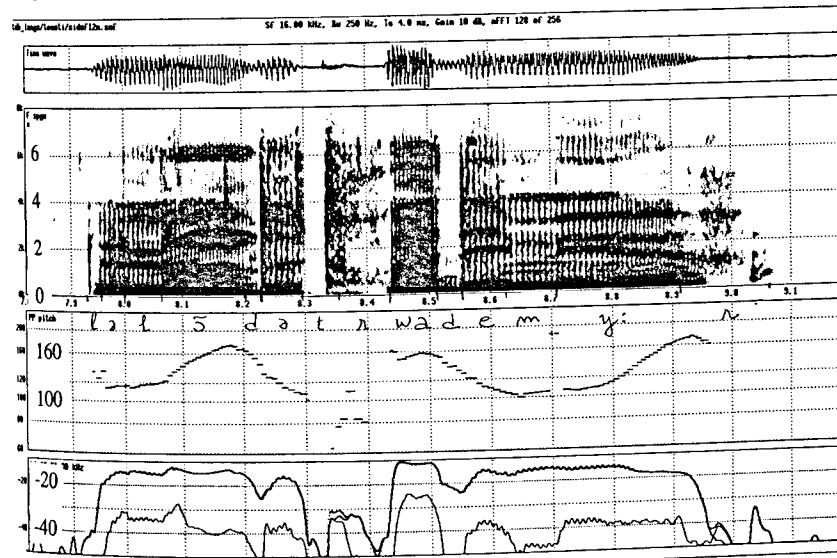


Figure 2. French prosodic phrase, "Le long de trois des murs". Oscillogram, spectrogram, log  $F_0$  and intensity, LP 1000 and HP 1000 Hz (below).

Figure 3 shows average syllable duration as a function of the number of phonemes per syllable comparing two French speakers and our Swedish reference speaker reading the same base text. Phrase-final syllables are excluded. The stressed/unstressed contrast is apparently lower in the French than in the Swedish data. Regression lines for

stressed and unstressed data converge for the French data but diverge for the Swedish data. This compression versus expansion of the duration of complex syllables adds to the language specific contrasts and can be quantified with reference to the constants of the regression equations.

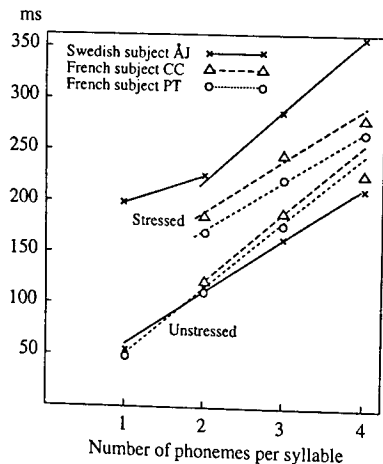


Figure 3. Syllable duration. One Swedish and two French subjects.

Table 1. Regression equations for syllable duration  $d=a+bn$  as a function of the number of phonemes per syllable.

	Unstressed	Stressed
Swedish, AJ	$d=9+51n$	$d=84+67n$
French, CC	$d=-11+66n$	$d=89+50n$
French, PT	$d=-10+63n$	$d=76+48n$

In Swedish the slope factor  $b$  is greater for stressed than unstressed syllables and the reverse is true for French.

Figure 4 contrasts high and low speaking rate for the French subject PT. The higher tempo reduces durations of both stressed and unstressed syllables to the effect that unstressed syllables of the lower speaking rate attain approximately the same durations as stressed syllables of the higher speaking rate. In Swedish the durational contrast is also reduced but to a less extent [2].

A wellknown feature is the extra long duration of phrase-final syllables in French [3]. A remarkable finding is that they stay approximately constant with reading rate. A study of pausing showed that in addition to 8 sentence final pauses there occurred 12 pauses within sentences at normal and high speech rate and 16 at a low speech rate. The more frequent pausing in slow speech is a well known phenomenon [4]. The effective reading time, pauses excluded, was 16% higher in the low than in the normal rate

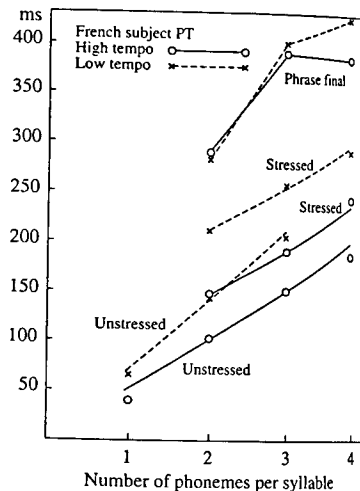


Figure 4. Syllable duration at high and low speech rate. French subject.

and 13% lower in the high than in the normal speaking rate. The ratio of pause time to effective reading time was close to 38% at both normal and low speaking rate and 22% at the high speaking rate.

#### PHONEME DURATIONS AND INHERENT LENGTH

These corpora are too small to allow a representative listing of the durations of individual vowels and consonants but there is a basis for considering certain group data, i.e. to what extent syllable duration is influenced by the relative occurrence of phonemes of inherently long durations and also how the stress induced lengthening affects the vowel and associated consonants. As already stated in [1], stress in French induces almost no lengthening of consonants following a vowel in a non-terminal syllable, the main effect to be observed is in the vowel and preceding consonants. In Swedish, consonants following a short stressed vowel carry a large part of the syllable lengthening. In English preceding and following consonants have about equal importance.

An example of segment duration profiles in French unstressed, stressed non-terminal, and stressed final syllables is shown in Figure 5. It pertains to 3-phoneme syllables of type CCV and CVC with segment notations C-2, C-1, V and C-1, V, C+1.

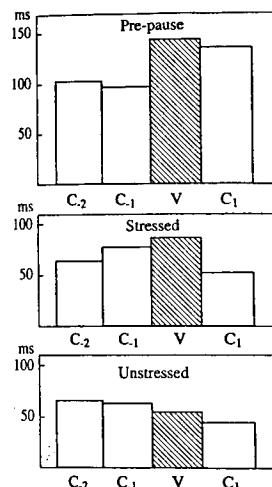


Figure 5. French segment durations in pre-pause, stressed and unstressed syllables.

It verifies the importance of the vowel as a primary object of stress induced lengthening and of consonants in non-terminal locations. In terminal prepause locations the final consonant adds significantly to the syllable duration.

An analysis of stressed versus unstressed CV sequences in non-terminal positions provided the following results. For speaker PT the difference in vowel duration was 28 ms and in consonant duration 19 ms, i.e. a total stressed/unstressed contrast of 47 ms. However, the more frequent occurrence of consonants of a relative large duration in stressed than in unstressed syllables, fricatives and unvoiced stops and also [b], accounted for 11 ms of the 19 ms difference in consonant duration. The stressed induced consonant lengthening was thus merely 19-11=8 ms. Similarly, the more frequent occurrence of nasal vowels and of the diphthong [wa] in stressed syllables contributed to 4 ms of the stressed/unstressed contrast. The true stressed induced vowel lengthening was thus 28-4=24 ms. Of the total C+V difference of 47 ms a net of 32 ms represented a true lengthening associated with stress. Similar figures were attained for speaker CC, i.e. 4 ms for inherent vowel duration and 8 ms for inherent consonant durations and a total of C+V=34+28=62 ms stressed/unstressed

difference of which 50 ms represents a true segment lengthening. Differences in inherent durations may also explain a part of the stressed/unstressed convergence in the French data, Figure 3. In Swedish the role of phoneme inherent durations was found to be insignificant since the distributions were quite similar in stressed and unstressed syllables.

#### CONCLUSION

In French a part of the observable average durational difference between stressed and unstressed syllables of the same number of phonemes is due to a larger proportion of phonemes of a relatively long inherent duration in stressed syllables. Regression lines for stressed and unstressed syllables converge in French but diverge in Swedish. These findings add to the two basic components of durational contrast, that of stress induced lengthening and the dominance of 2-phoneme syllables in French. The smaller total durational contrast between stressed and unstressed syllables in French supports the view of French as a syllable timed and Swedish as a stress timed language. The rhythm of French is, however, a more complicated question. The sequence of prosodic words also carry a rhythmical pattern.

#### ACKNOWLEDGEMENT

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