

Do Danes speak more quickly than Swedes?

Anja Schüppert^{1,*}, Charlotte Gooskens¹, Vincent van Heuven²

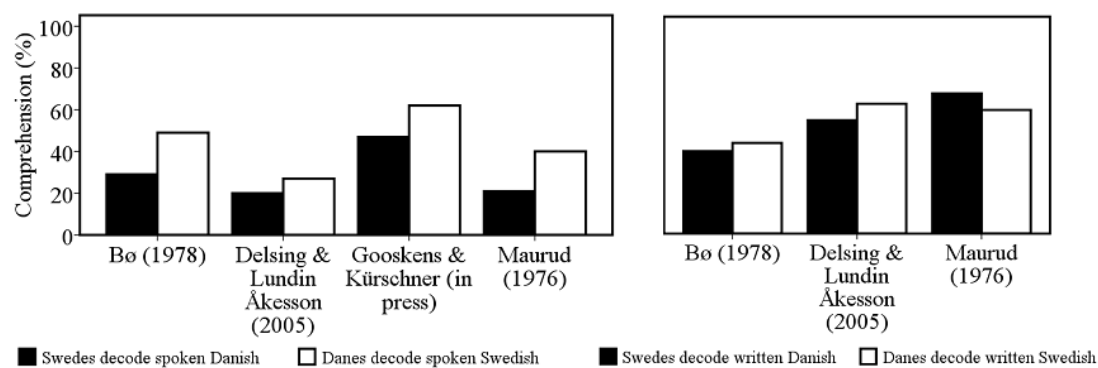
¹University of Groningen, The Netherlands

²Leiden University, The Netherlands

1. Introduction

Danish and Swedish are two closely related North Germanic languages that have been shown to be mutually intelligible to a certain extent, both in written and spoken form (Maurud 1978, Bø 1978, Delsing & Lundin Åkesson 2005, Schüppert & Gooskens in press). This is illustrated in Figure 1, where mean comprehension scores of spoken (left) and written language (right) from different studies are displayed.

Figure 1. Left: Mean comprehension of spoken Danish by Swedish adults and of spoken Swedish by Danish adults. Right: Mean comprehension of written Danish by Swedish adults and of written Swedish by Danish adults.



A comparison of the two bar graphs shown in Figure 1 not only reveals that comprehension of written language is generally higher than comprehension of spoken language, but also that the degree of spoken language comprehension varies depending on which of the two languages is spoken. This is not the case for written language. In the studies cited, it has consistently been shown that Danish-speaking adults have fewer difficulties to understand spoken Swedish than vice versa, but written language comprehension is symmetric. This suggests that properties of spoken language that are not found in written language cause the asymmetry in mutual comprehension. One of the properties found in spoken language only, is speech rate.

Apart from the findings by Maurud (1978), Bø (1978), Delsing & Lundin Åkesson (2005), and Schüppert & Gooskens (in press) on mutual comprehension, there is evidence that the vocabulary development in Danish infants and children aged between 0;8 and 1;8 years lags behind that of their peers from ten European countries and from the US and Mexico (Bleses et al. 2008). Bleses et al. hypothesize that this is due to some specific features of Danish phonology. For example, a syllable-final *lrl* is realized as a pharyngeal glide in standard Danish (Basbøll 2005: 150), and schwa deletion is either optional or obligatory in a number of contexts (Basbøll 2005: 293). With [ʊ] and [ø], Danish has two approximants, that correspond to obstruents in Swedish in many contexts. Furthermore, these approximants are subject to optional lenition or deletion (Pharao 2009). Taken together, these facts result in fewer cues to segmentation in Danish, compared to Swedish, for example, which makes it more difficult to identify segment boundaries, both for children and adults. We hypothesize that, cross-linguistically, the amount of lenition and reduction correlates positively with speech rate, i.e. the more reduction and lenition in a language, the faster the speech rate of that language.

Speech rate has been investigated cross-linguistically by different researchers. Osser and Peng (1964) compared American English to Japanese, and did not find a significant difference in speech rate between these two languages. Neither did Kowal, Wiese, and O'Connell (1983), who re-evaluated findings from earlier studies based on spontaneous speech in English, German, French, Spanish, and Finnish. Den Os (1988) conducted a comparative study on Italian and Dutch, and made a distinction between articulation rate (pauses not included), and speech rate (pauses included). She analysed the tempo of reading aloud in six male native Italian and six male native Dutch speakers and did not find a significant difference in either articulation rate or speech rate, when syllables per second were compared across languages. When phonemes per second were compared, however, Italian articulation and speech rate were both significantly slower than Dutch articulation and speech rate. Verhoeven, de Pauw & Kloots (2004) compared speech tempo in Belgian and Netherlandic Dutch and found that Netherlandic Dutch is spoken with a significantly higher speech rate than Belgian Dutch.

In this paper, we investigate Danish and Swedish articulation rate. We hypothesize that Danish is spoken more quickly than Swedish. As previous research has shown that a higher speech rate impairs intelligibility (Vaughan & Letowski 1997, Gordon-Salant et al. 2007), such an asymmetry in speech rate might cause or increase the asymmetry in comprehension by impairing the intelligibility of spoken Danish for Swedish-speaking listeners.

2. Method

To be able to compare speech rates across the two languages, we used material that consisted exclusively of cognates. Our material was developed by Gooskens, Van Heuven, Van Bezooijen & Pacilly (submitted).

2.1. Material

We based our measurements on two kinds of material: short read sentences and isolated cognate nouns. The use of read sentences allows us to include the same types of sentences with the same cognate words in both languages and for all speakers. There is an inverse relationship between number of words in a sentence and speech rate (Fonagy & Magdics 1960, Malecot et al. 1972). This means that words in long sentences are pronounced more quickly than words in short sentences. We therefore expect the mean speech rate of the isolated words in our material to be lower than that of the words in the read sentences. In the next sections we will go into detail about the two kinds of stimulus material.

2.1.1 Sentences

To construct sentences, the so-called SUS-generator was used that was developed by Benoît et al. (1996). The SUS generator produces Semantically Unpredictable Sentences, which can be used to measure overall intelligibility. The generator was originally developed for the evaluation of the intelligibility of text-to-speech systems at the sentence level, but it is also a useful method for testing the intelligibility of natural language. The sentences are syntactically correct but semantically anomalous.

Listeners receive cues as to syntactic category only but other than that they will not be able to make any further predictions about word identity by means of semantic or syntactic contextual cues. An example of a SUS sentence is given in Table 1.

The SUS-sentences can be automatically generated using basic syntactic structures and a number of lexicons containing the most frequently occurring short words in each language. The syntactic structures are simple and the sentence length does not exceed seven words. All words are selected from the most frequent words in their syntactic category using published databases which list words in terms of their token frequency in written texts or spoken recordings. Only those words containing the smallest number of syllables within a word class are used. This means that most words are monosyllabic.

Table 1. *An example of the same sentence in Danish and Swedish.*

| | |
|----------------|---|
| Danish | <i>Et folk deler et job som går.</i> |
| Swedish | <i>Ett folk delar ett jobb som går.</i> |
| English | 'A nation shares a job that walks.' |

Sixteen different SUS sentences were generated. They consisted of three sentences from each of four syntactic structures. In order to counterbalance possible language-specific influences such as differences in word frequency, half of the sixteen SUS sentences originated from the Swedish SUS generator and the other half from the Danish SUS generator. The Swedish sentences were then translated into Danish and the Danish sentences into Swedish so that in total we had the same twelve sentences in Swedish and in Danish. The syntax of Swedish is so similar to the Danish syntax

and the four syntactic structures are so simple and general that it provided no problems to translate the Swedish sentences word for word into Danish or visa versa. For a detailed account of the derivation of the SUS-material see Gooskens et al. (submitted).

2.1.2. *Isolated words*

We took care to select the isolated words on the basis of the same criteria as the words in the read sentences. This makes it possible to compare the results. 32 words were selected in the same way as the words in the SUS-generator. This means that all words were frequent monosyllabic cognates. Only nouns in the singular form were used. Examples are given in Table 2.

Table 2. *Examples of isolated words.*

| Danish | Swedish | English |
|--------------|---------------|-----------|
| hund [hunʔ] | hund [ˈhønd] | ‘dog’ |
| hav [haʊ] | hav [ha:v] | ‘sea’ |
| luft [lofd] | luft [ˈløft] | ‘air’ |
| bror [brø:p] | bror [ˈbrʊ:r] | ‘brother’ |

2.2. *Speakers*

The speakers were three Danish and three Swedish native speakers. The Danish speakers were current or former linguistics students from Copenhagen ailing from the greater Copenhagen area. They were approximately 30 years old. The Swedish speakers were matched as well as possible with the Danish speakers. They were male,

about 30 years old, and current or former linguistics students from the greater Stockholm area.

2.3. Procedure

The six speakers read aloud the sixteen sentences and the 32 isolated words in sound-attenuated rooms. The sound files were segmented by two speakers of Danish and Swedish, respectively, using the phonetics software PRAAT, version 5.0.43.

To test our hypothesis, we compared Danish and Swedish speech rate in three male native speakers for each language. Previous investigations mainly defined speech rate as the number of syllables produced per second (Kowal, Wiese, and O'Connell 1983, Den Os 1988, Verhoeven, de Pauw & Kloots 2004). To be able to compare our results to these studies, we define speech rate in the same way. As we are interested in comparing Danish speech rate to Swedish speech rate, however, our calculation of the number of syllables produced is based on the underlying phonological form of every word. For example, the Danish word *svarer* ('to answer') is interpreted as having two syllables, as is the Swedish cognate *svarar*. The Danish word, however, is pronounced [sva:], i.e. as a monosyllabic word, whereas the Swedish counterpart is pronounced disyllabically [sva:rar]. However, the underlying form of this word is disyllabic also for Danish listeners. This definition was based on the assumption that it might be exactly those reduction processes that make it hard for Swedish listeners to comprehend spoken Danish.

Additionally, as we are mainly interested in comparing Danish to Swedish speech rate, we use communication rate as a measure of how quickly a specific message can be communicated to listeners. Communication rate is defined as the

number of concepts produced per second. As our material only consists of cognates, this is equal to the number of words produced per second.

Our material consisted of isolated words and short sentences. That means that our speakers did not have the possibility to make pauses. Therefore, we do not carry out separate analyses for speech rate, but analyse articulation rate in our speakers, only.

3. Results

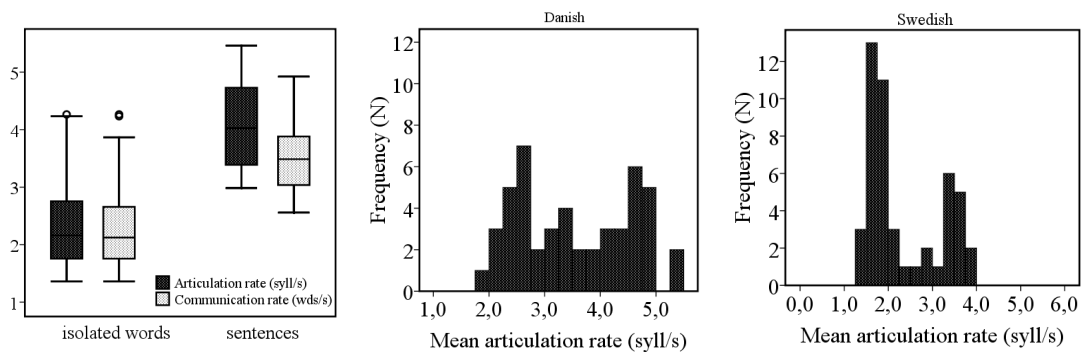
Our hypothesis was that Danish is spoken at a higher articulation and communication rate than Swedish. We tested this hypothesis by comparing Danish mean articulation and mean communication rate to Swedish mean articulation and mean communication rate.

A Kolmogorov-Smirnov test with Lilliefors correction showed that articulation rate was not normally distributed in our data ($z(96) = 0.10, p = .01$). This is obviously caused by the fact that, in both languages, articulation rate is significantly higher in sentences (4.03 syll/s) than in isolated words (2.16 syll/s, $U = 133, p < .001$). This result is in line with earlier findings (Fonagy & Magdics 1960, Malecot et al. 1972, see Section 2.1.), and is illustrated in Figure 2, which shows mean articulation rate for isolated words and sentences averaged across speakers in a box plot graph. It can be seen that the frequency distributions for sentences and words hardly overlap, which creates a non-normal, M-shaped distribution, which is illustrated in Figure 2. A similar pattern is found for communication rate, as can be seen in Figure 2.

We therefore analyse articulation and communication rate separately for isolated words and sentences. That means that we have four groups of data: Danish isolated

words, Danish sentences, Swedish isolated words, and Swedish sentences. The data for these four groups was normally distributed, $z(32) = 0.15$, $p = .07$ for Danish and Swedish isolated words, $z(16) = 0.12$, $p = .20$ for Danish sentences, and $z(16) = 0.16$, $p = .20$ for Swedish sentences.

Figure 2. Left: Mean articulation and communication rate for isolated words and sentences averaged across speakers. Centre: Mean articulation rate frequencies for Danish speakers. Right: Mean articulation rate frequencies for Swedish speakers.

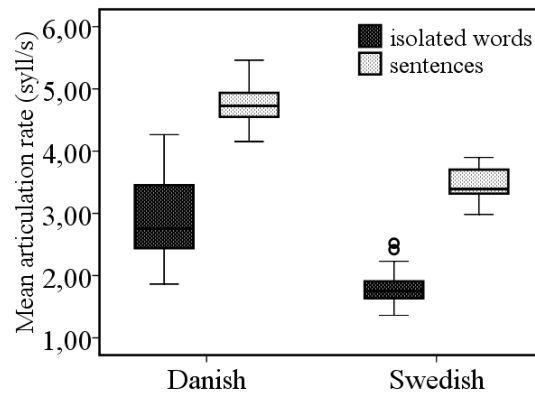


3.1. Danish versus Swedish articulation rate

A paired-samples t-test with Danish and Swedish articulation rate as variable pair revealed that the isolated words were produced at a significantly higher articulation rate in Danish ($\mu = 2.94$ syll/s) than in Swedish ($\mu = 1.80$ syll/s, $t(31) = 10.95$, $p < .001$). The same pattern is found in the sentence material. Danish mean articulation rate at 4.75 syll/s is significantly higher ($t(15) = 14.47$, $p < .001$) than Swedish mean articulation rate at 3.45 syll/s. That means that Swedish articulation rate is 61 percent of the Danish rate in isolated words, and 73 percent of the Danish rate in read

sentences. These results are displayed in Figure 3, which shows mean articulation rate averaged over three speakers per language, broken down by utterance length.

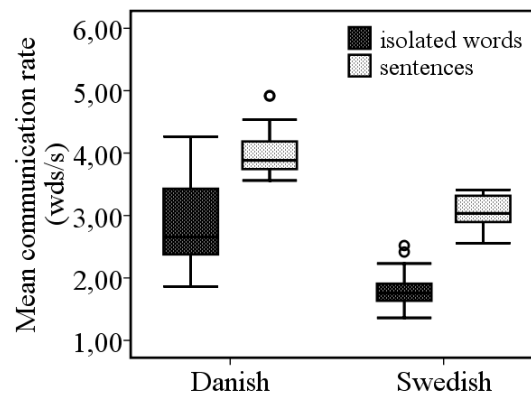
Figure 3. Mean articulation rate for Danish and Swedish, broken down by utterance length.



3.2. Danish versus Swedish communication rate

Also communication rate is nonnormally distributed and therefore analyzed separately for isolated words and sentences. All four groups of data were normally distributed, $z(32) = 0.15, p = .07$ for Danish and Swedish isolated words, $z(16) = 0.20, p = .11$ for Danish sentences, and $z(16) = 0.16, p = .20$ for Swedish sentences. A paired-samples t-test with Danish and Swedish communication rate as variable pair revealed that even communication rate is significantly higher ($t(31) = 10.62$) for Danish isolated words ($\mu = 2.87$ wds/s) than in Swedish isolated words ($\mu = 1.80$ wds/s). Also the sentence content is communicated quicker in Danish ($\mu = 4.04$) than in Swedish ($\mu = 3.04$). That means that that Swedish communication rate is 63 percent of the Danish rate in isolated words, and about 75 percent of the Danish rate in read sentences. Figure 4 displays these results.

Figure 4. Box plot graph showing mean articulation rate for Danish and Swedish, broken down by utterance length.



4. Discussion and conclusion

We hypothesized that the larger amount of reduction and lenition in Danish compared to Swedish correlates with a higher Danish speech rate. In section 3., a significant difference in articulation and communication rate between Danish and Swedish was found, revealing that Danish is spoken between 25 percent and 39 percent more quickly than Swedish, depending on utterance length. Our hypothesis is therefore confirmed. From our data, however, it is not clear which of these factors is cause and which is effect. It might be the case that our Danish speakers tend to reduce phonemes because they speak fast, but it is also possible that they have the possibility to speak faster because there are more legal reduction processes in Danish than in Swedish. This question can only be answered in a follow-up study.

It is noteworthy that articulation and communication rates in Danish and Swedish in our data is much slower than the values reported by Kowal et al. (1984), Den Os (1988) and by Verhoeven et al. (2004). Den Os found that, in a reading task, speakers of Dutch produce 6.1 syllables per second, and speakers of Italian produce 6.4

syllables per second. Verhoeven et al. reported that, in spontaneous speech, speakers of Netherlandic Dutch produced 5.05 syllables per second, and speakers of Belgian Dutch produced 4.23 syllables per second. Also the articulation rate figures from different studies reported by Kowal et al. (1984), that are based on a broad range of studies, deviate strongly from our findings. Kowal et al. (1984) reported rates between 2.87 syll/s and 5.48 syll/s for English, 4.09 syll/s and 6.76 syll/s for German, 3.69 syll/s and 5.05 syll/s for French, 6.08 for Spanish, and 5.08 for Finnish. It is possible that the huge differences in articulation rate between our data and the studies reported above are due to the fact that, in our study, the calculation of syllables per second is based on underlying phonology rather than actual pronunciation. However, the cited literature does not give exact accounts of the way the syllables are defined for their purposes.

Also, our material consisted to a high extent of monosyllabic words, and our sentence material consistend of rather short sentences. As our data, in line with earlier research, shows that there is a strong relationship between utterance length and speech rate in general, this might have a detrimental effect on articulation and comunication rates in our data.

Another difference between our and the aforementioned studies is the fact that all other studies analyzed spontaneous speech. Walker & Archibald (1992) provided evidence that, in children, spontaneous speech is faster than imitated speech. It is likely that the same is true for adult speakers. However, as we aimed at directly comparing speech rate in the two languages Danish and Swedish, we chose to analyse cognates only, which made it difficult to use spontaneous speech. Future work should therefore focus on the analysis of spontaneous speech in Danish and Swedish, to confirm our findings.

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