Do Danes speak more quickly than Swedes?

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Abstract

Within Scandinavia, communication across language borders often takes place in the native languages of the involved speakers. The East Scandinavian languages Danish and Swedish are closely related and thus mutually intelligible to a certain degree. However, mutual intelligibility between speakers of Danish and Swedish has been shown to be asymmetric in such a way that Danes generally decode more spoken Swedish items than vice versa.

As there is extensive evidence that articulation rate affects intelligibility for native speakers, we assume that even cross-linguistically, higher articulation rate is associated with lower intelligibility, and hypothesise that Danish is spoken at a faster rate than Swedish. We test this hypothesis by investigating phonetic articulation rate (the number of phonetic syllables produced per second) and lexical articulation rate (the number of words produced per second) in two corpora of spoken Danish and Swedish that can be assumed to be intelligible to most L1 speakers of the two speech communities: news broadcasts.

Our results show that Danish- and Swedish-speaking news readers produce the same number of phonetic syllables per second, while Danish-speaking news readers produce significantly more words per second than their Swedish-speaking colleagues.

1. Introduction

Danish and Swedish are closely related languages belonging to the East Scandinavian branch of the North Germanic language family. As Tang & Van Heuven (2009) point out, closely related languages usually share a substantial number of cognate words. Within this set of cognates, most cognate words are expected to exhibit regular sound correspondences. A high number of such lexical and phonetic similarities across linguistic varieties are likely to increase mutual intelligibility between these varieties. Indeed, Danish and Swedish have been shown to be mutually intelligible to a certain extent, both in written and spoken form (Schüppert 2011, Gooskens, Van Heuven, Van Bezooijen & Pacilly 2010, Delsing & Lundin Åkesson 2005, Bø 1978, Maurud 1976). Their close relationship allows speakers of the two languages to communicate with each other using their native languages. This means that in a conversational situation a speaker of Danish might speak Danish to a speaker of Swedish, who then replies in Swedish. However, in the studies cited above, it has quite consistently been shown that Danish-speaking adults have fewer difficulties decoding spoken Swedish than vice versa, whereas written language intelligibility is symmetric. This suggests that properties of spoken language that are not

found in written language cause this asymmetry in mutual intelligibility of spoken language. One of the properties found in spoken language only is articulation rate, which is the focus of this paper.

Articulation rate, generally, is defined as the number of entities (phonemes, syllables, words, etc.) divided by the time it takes to complete the utterance, but excluding pauses. A related measurement is *speech rate*, which is defined as the number of syllables produced per time interval including pauses. That means, the shorter the duration of segments, syllables or words, the higher the speech rate and the articulation rate. Duration of different linguistic entities and articulation rate are therefore closely linked.

Duration, again, seems to be linked to word and syllable stress. Stressed syllables generally have a longer duration than unstressed syllables (Janse, Noteboom & Quené 2003, Sluijter & Van Heuven 1996). On a phonetic level, it was shown that open vowels tend to be longer than closed vowels (Van Heuven & Sluijter 1996) and that vowels generally have a longer duration when they precede a voiced obstruent than when they precede a voiceless obstruent (Van Heuven & Sluijter 1996). Van Heuven (1994) points out that speech rate tends to be higher at the beginning of an utterance than at the end, and for read speech, utterances at the beginning of a paragraph are usually produced at a higher rate than those located later in a paragraph. Likewise, speech rate is higher at the beginning of words than at their end. Furthermore, long utterances are generally produced at a higher rate than short utterances. Also clause type seems to affect speech rate. Van Heuven & Van Zanten (2005) report that speakers of Dutch, Orkney English and Manado Malay produce interrogative sentences with a higher speaking rate than declarative sentences.

It has not been investigated whether the above reported processes are universal, but due to perceptual and articulatory constraints, a similarly distributed variation in syllable and phoneme duration can be assumed to be found in most types of speech, independent of the speakers' age, sex, or linguistic variety involved. However, apart from more general tendencies of variation in syllable and phoneme durations, also speaker- and language-specific variation in speech and articulation rates have been reported. Both measurements vary between as well as within speakers and speaker communities, as has extensively been confirmed in studies investigating context-related, age-related and sex-related variation in speech and articulation rate. Ramig (1983) showed that elderly speakers of English generally speak at a slower rate than younger speakers, although this effect was significantly stronger in participants with 'poor' physiological

condition than in those with 'good' physiological condition. This difference has been confirmed by Verhoeven, De Pauw & Kloots (2004) for varieties of Dutch, and by Jacewicz, Fox, O' Neill & Salmons (2009) for varieties of English. In studies on English, Dutch and Chinese it has been reported that men tend to speak faster than women (e.g. Jacewicz, Fox, O' Neill & Salmons 2009, Yuan, Liberman & Cieri 2006, Verhoeven, De Pauw & Kloots 2004), although Robb, Maclagan & Chen (2004) and Van Borsel & De Maesschaelck (2008) could not establish any sex-related differences.

The focus of this study is on regional variation of articulation rate. Cross-variety variation has been reported in a number of studies, analysing either articulation rate, or speech rate, or both. Robb, Maclagan & Chen (2004) compared articulation rate in Christchurch English (New Zealand) and Connecticut English (United States). They report that New Zealand English is spoken at a higher rate than American English and suggest that this higher articulation rate might be linked to reduction processes in New Zealand English. Verhoeven, De Pauw & Kloots (2004) compared articulation rate in Belgian and Netherlandic Dutch and found that Netherlandic Dutch is articulated at a significantly higher rate than Belgian Dutch. Jacewicz, Fox, O'Neill & Salmons (2009) compared American English speakers from Wisconsin with speakers from North Carolina and report regional differences in articulation rate, with Wisconsin speakers speaking significantly faster than speakers from North Carolina. These studies compare different regional varieties of *one* language to each other.

One of the first studies investigating speech rate cross-linguistically, i.e. across *different* languages, was conducted by Osser & Peng (1964), who compared the number of phones produced per minute by native speakers of American English and by native speakers of Japanese. They report no significant cross-linguistic difference in speech rate. Kowal, Wiese & O'Connell (1983) re-evaluated findings from earlier studies based on spontaneous speech in English, German, French, Spanish, and Finnish. They report articulation rates between 4.1 syllables per second (for German) and 6.1 syllables per second (for Spanish). Den Os (1988) conducted a comparative study on Italian and Dutch speech rate. She analysed the tempo of reading aloud in native speakers of Italian and Dutch and did not find a significant difference when syllables per second were compared across languages. When the number of phones per second were compared, however, Italian speech rate turned out to be significantly slower than Dutch speech rate.

In this paper, we investigate differences in articulation rates between speakers of Danish and Swedish. We hypothesise that Danish is spoken

more quickly than Swedish, which is manifested by a higher articulation rate. We define two different measures of articulation rate: (i) phonetic articulation rate (the number of phonetic syllables produced per second) and (ii) lexical articulation rate (the number of words produced per second).

As previous research has shown that a higher articulation rate generally impairs intelligibility (Gordon-Salant, Fitzgibbons & Friedman 2007, Vaughan & Letowski 1997), a higher articulation rate in Danish could be a reason why spoken Danish is less intelligible to speakers of Swedish than vice versa. However, intelligibility has been found to decrease only if the speech contains more reduction, and not if a well-articulated speech sample is time-compressed (Janse 2004). In this paper, we analyse natural speech and therefore assume that a higher articulation rate is linked to a higher amount of reduction in our speech sample. The link between articulation rate and intelligibility is not experimentally investigated here, however. Rather, the aim of this paper is of descriptive nature.

2. Phonetic articulation rate

2.1 Material

As this study investigates potential differences in articulation rate between closely related languages, it is important to base the analysis on similar types of speech samples in both languages. More specifically, variables such as age and sex should be kept constant across the languages involved. As this descriptive study investigates a feature which might account for the asymmetry in mutual intelligibility of spoken Danish and Swedish, we felt the need to ensure that the speech samples analysed can be assumed to be equally intelligible to the two groups of native speakers.

We assume that these prerequisites are met by news broadcasts from *Danmarks radio* (DR) and *Sveriges Radio* (SR). Both radio stations are non-commercial public service-stations. We analysed recordings from the following programmes: Ekonyheter (SR), Stockholmsnytt (SR), P3 Nyheter (SR), Radioavisen (DR) and P4 København (DR). From nineteen Danish and eighteen Swedish recordings, each read by a different speaker, samples of roughly thirty seconds were selected that fulfilled two criteria: (i) they were noise-free (no background music) and (ii) coherent (not interspersed with speech by other people). No interviews or other types of spontaneous speech were included.

In both languages, nine recordings were produced by women. The total duration of every sample varied between 25.7 and 39.0 seconds (M = 30.0 seconds) for Danish and between 21.1 and 38.1 seconds (M = 27.8 seconds) for Swedish speakers.

Heegård & Thøgersen (2012) investigated reduction phenomena in Danish news readings and spontaneous speech. They report that some phenomena are more frequent in read news, while others appear more frequently in spontaneous speech. It might therefore be the case that our corpus of news readings is not entirely representative for all kinds of registers, although the study by Heegård & Thøgersen (2012) did not show this systematically. However, we assume that the two corpora are highly comparable across the two languages involved, which is central for a cross-linguistic comparison.

2.2 Method

A closer inspection of the material revealed that there were substantial between-speaker differences in the number and the length of pauses. We therefore opted for the removal of all pauses longer than 150 ms.

Most studies investigating speech or articulation rates base their measurements on canonical syllables. However, as our results are interpreted from a cross-linguistic point of view, we are also interested in the acoustic information that signals listeners actually receive when confronted with the neighbouring language. Therefore, we decided to count the number of phonetic syllables in the corpora. A problem with this approach, however, is that phonetic syllables can be defined from different perspectives, for example from an articulatory, acoustic, or perceptional point of view. Davenport & Hannahs (2010) discuss the articulatory features on which such a definition could be based, such as muscle contractions in the lungs and/or in the vocal tract. They point out, however, that muscular energy is more suitable for defining phonetic syllables in languages closer to the syllable-timed end of the isochony continuum, than in those which are closer to the stress-timed end of it. As Danish and Swedish are stress-timed languages, this might not be a suitable definition. A perceptual approach would involve native speakers' judgments as to how many syllables an utterance contains. It is likely that native speakers who fully understand the meaning of every utterance would identify more syllables in the speech signal than both non-native speakers and an automatised syllable detection algorithm, because their knowledge of orthography will interfere with the purely acoustic signal. Knight (2012)

follows the classical, acoustic approach which defines a syllable as consisting of at least one obligatory element, namely a sonorant. We adopt a similar definition by De Jong & Wempe (2009) of syllable nuclei as intensity peaks in speech signal with voicing. More specifically, the intensity preceding and following the peak is at least 2 dB lower than at the peak. Using a script for PRAAT (Boersma & Weenink 2009) which was developed by De Jong & Wempe (2009), syllable nuclei were detected automatically with these parameters.

An example of the output of the automatic procedure is shown in Figure 1. The upper part of the figure shows the oscillogram of the fragment *skatteydere der ikke* ('taxpayers who do not') read by a male Danish news reader. The central part of the figure shows the cochleagram with intensity (black line) and pitch curves (white line), and the lower part shows a grid that marks sonority peaks and gives an orthographic transcription for each detected peak. The fragment contains three words and eight canonical syllables (skat.te.y.de.re.der.ik.ke), but only four intensity peaks are detected in those parts of the signal that have voicing, as can be seen in the syllable tier displayed underneath the cochleagram. In other words, the algorithm detects four phoneic syllables in this speech fragment.

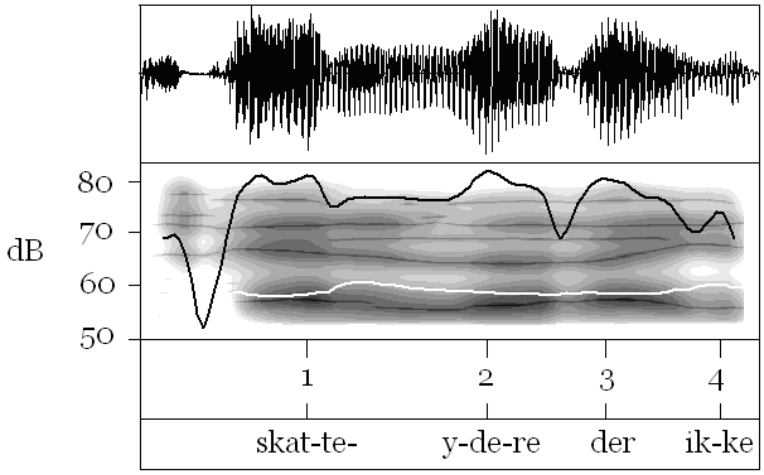

Figure 1: *Oscillogram (upper panel), cochleagram (central panel) with intensity curve (black line) and pitch contour (white line) as well as syllable tier and orthographic transcription (lower panel) for the fragment* skatteydere der ikke *('taxpayers who did not') read by a Danish news reader.*

In order to obtain individual phonetic articulation rate per speaker, the number of phonetic syllables produced by every speaker is simply divided by the duration of the analysed sample for this speaker.

2.3. Results

Contrary to our initial hypothesis, Danish (M = 4.4) and Swedish speakers (M = 4.5) produced the same number of phonetic syllables per second ($t(35)$ = 1.05, p = .3). Figure 2 illustrates the distribution of articulation rates per language in a box plot.

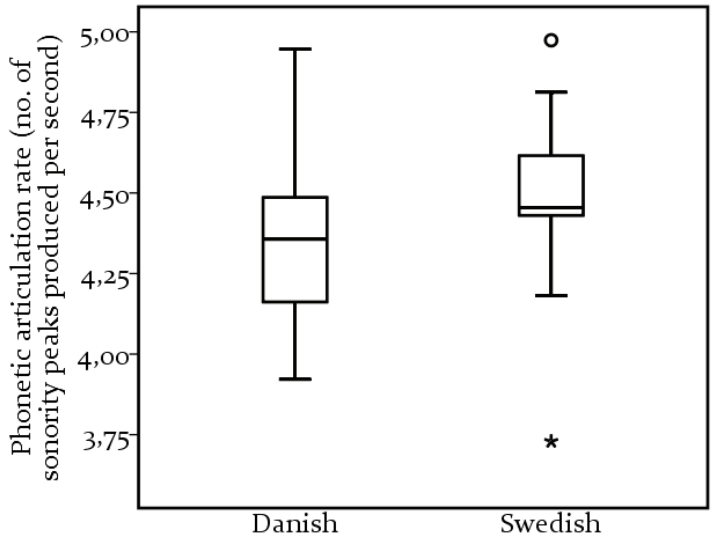

Figure 2: Median and inter-quartile phonetic articulation rate (number of sonority peaks produced per second) for both groups of speakers

3. Lexical articulation rate

3.1 Material

The same material as in Section 2 was used.

3.2 Method

The number of words was counted for every sample. On the basis of these figures, lexical articulation rate, defined as the number of words produced per second, was calculated for every speaker.

3.3 Results

The average Danish news reader in our corpus produced 3.1 words per second, whereas the average Swedish speaker produced 2.8 words per second. An independent *t*-test confirmed that this difference is significant ($t(35) = 2.4$, $p = .02$). This means that Danish lexical articulation rate is about 111 percent of the Swedish rate. Given the high lexical and morphological similarity of the two languages, this suggests that a specific message is generally transferred more quickly in Danish than in Swedish.

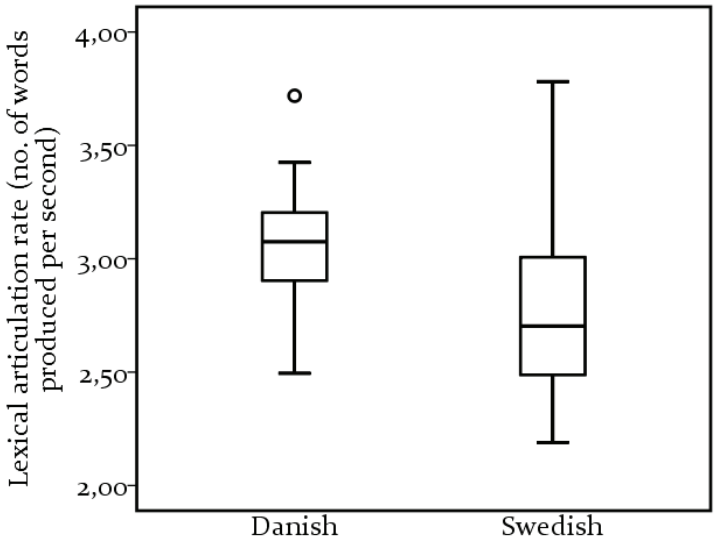

Figure 3: Median and inter-quartile lexical articulation rate (number of words produced per second) for both groups of speakers

4. Discussion

The fact that speakers of Danish are able to produce more words per second than their Swedish colleagues might be due to different diachronic processes in Danish and Swedish. One of the most prominent reduction rules in spoken Swedish is /r/ elision. A canonical /r/ is elided if it occurs before one or several tokens of canonical /d l n s t/. These phonemes, in turn, are supradentalised to /ɖ ɭ ɳ ʂ ʈ/, such as in /bɑːɳ/ for *barn* 'child', or /bɑːɳʂʈʉːga/ in *barnstuga* 'children's room' (Garlén 1988). Another rule changes the clusters /sk sj stj skj/ into /ɧ/. Both processes apply also across morpheme and word boundaries, such as in /ɧyn:daʂɛj/ for *skyndar sig* 'hurries up', or /jɛɧiv(ə)riː/ for *gästgiveri* 'inn'. In the latter one, a prominent lenition rule changes the two underlying /g/ phonemes into

/j/, because they occur before the front vowels /ɛ/ and /i/. The latter /j/ merges with the preceding /st/ to /ʃj/. Similarly to this rule, /k/ is lenited into /ç/ before front vowels, such as in /çœːra/ for *köra* 'to drive'.

In Danish, however, as in some other Germanic languages, schwa-deletion is a prominent characteristic. Schwa-assimilation is obligatory if schwa occurs before sonorants, and favoured if it occurs after a sonorant (Basbøll 2005: 293). Another prominent feature of Danish phonology is consonant lenition. The phoneme /r/ is realised as the approximant [ɐ̯] in postvocalic position, and is deleted in postvocalic position in syllables preceding a stressed syllable (Grønnum 2007: 115), while it is usually preserved in standard Swedish. For example, *skærm* 'screen' is pronounced [sgæɐ̯ˀm] (Hjort & Kristensen 2003) in Danish, while its Swedish cognate word *skärm* is pronounced [ʃjærm]. That means that in an –[rVrV] string such as in *lærere* 'teachers', the two tokens of /r/ become approximants and the schwa's are fused with them or even deleted, resulting in the phonetic realisation [lɛːʌʌ]. Other consonants that have been lenited in intervocalic position several centuries ago are /d/ and to /v/. With the lenited sounds /ð/ and /ʊ/, Danish has two approximants corresponding to obstruents in Swedish, namely to /d/ and to /v/, respectively.

Schachtenhaufen (2010) provides a valuable overview of reduction phenomena in colloquial Danish and concludes that the sound changes which took place in Danish during the last centuries have led to a general lack of articulatory and acoustic cues. Our data fits well to this statement. This conclusion is also in line with Bleses et al. (2008), who report that Danish infants and children lag behind their peers from other countries in vocabulary comprehension. They suggest that this is caused or boostered by the high number of reduction and assimilation processes in Danish. In line with this finding, Vanhove, Leinonen, Van Heuven & Gooskens (2010) showed that Danish vowels are significantly less precisely articulated than Swedish vowels are. More research into the role of the different correlates of reduced speech on intelligibility is necessary.

It might be the case that the differences in the language-specific lenition and reduction processes have implications for articulatory, acoustic and perceptual correlates. For example, it is possible that producing a [rVrV] string requires more articulatory energy than producing a purely vocalic string such as [ɛːʌʌ]. However, this argumentation can also be turned around. In contrast to Danish, Swedish allows for geminate consonants in stems. For example, in the Swedish place name *Backa* [bak:a], the geminate /k/ is pronounced with a longer duration than in the word *baka* [bɑ:ka] 'to bake', in which the vowel has a longer duration than in *Backa*.

This type of consonant geminate does not exist in Danish stems. It does exist across morpheme boundaries in Danish, however, where it even functions as distinctive feature. For example, in the Danish word *bundne* [b̥ɔn:ə] 'bound (pl.)', the /n/ has a longer duration than in the word *bunde* [b̥ɔnə] 'bottoms', but a shorter duration than in the word bundene [b̥ɔn:nə] 'the bottoms'. Notably, geminate constructions in Danish are usually a consequence of sound deletions, which is not the case in Swedish. In other words, for a geminate consonant to appear in Danish, some segments have to be dropped, while in Swedish, the consonants /b d f g k l m n p r s t/ can, and very frequently do, appear both as simple and geminate forms, irrespective whether any sounds surrounding the consonant have been deleted or not. In colloquial Swedish, it is possible to produce *bundna* 'bound (pl.)' as [bɵn:a], but [bɵndna] would be a more acceptable form of the word in distinct speech.

Arguably, for articulatory reasons, it takes less time to complete a highly reduced utterance than a hyperarticulated one (Rietveld & Van Heuven 2009). Also, speaking fast almost inevitably leads to less accurate articulation (less pitch movements, more co-articulation, and fewer syllables), so phoneme shortening and phoneme deletion is linked to higher articulation rate, and vice versa. It is not clear, however, which is 'cause' and which is 'effect'. In other words, we do not know whether synchronic and diachronic lenition and assimilation processes cause a higher articulation rate in Danish, or whether the higher articulation rate has led to more lenition and assimilation processes.

5. Conclusion

We hypothesised that speakers of Danish speak faster than speakers of Swedish do. This hypothesis was tested by investigating phonetic and lexical articulation rates in news readers from non-commercial public service-stations in Denmark and Sweden. The choice of the material was motivated by the assumption that news readers generally can be considered to speak in a way that makes their speech intelligible to a broad audience.

In Section 2.1.3., contrary to our original hypothesis, we found that Danish and Swedish newsreaders produce the same number of phonetic syllable nuclei per time interval. A syllable nucleus, here, was defined as a voiced intensity peak preceding and following an intensity dip (De Jong & Wempe 2009). Subsequently, we found that Danish news readers produce significantly more words per second than their colleagues in Sweden do. We assume that this is due to a higher amount of diachronic lenition and

reduction processes in Danish compared to Swedish. Although we have no evidence for this, it might be the case that Swedish news broadcasts are linguistically more formal than Danish news broadcasts and therefore contain less distinct speech. Future research should investigate this.

Based on findings that higher speech rate impairs L1 intelligibility (Gordon-Salant, Fitzgibbons & Friedman 2007, Vaughan & Letowski 1997), it could be assumed that differences in articulation rate between spoken Danish and Swedish at least partly account for the well-documented asymmetry in mutual intelligibility between the spoken forms of these languages. This assumption should be tested experimentally by future research, however. If this proves to be the case, it is possible that different correlates of articulation rate (such as co-articulation, phoneme shortening or deletion, syllable reduction or deletion etc.) have different effects on intelligibility. Schüppert, Gooskens, Hilton & Van Heuven (2012), for instance, provide evidence that a higher articulation rate as such not only impairs intelligibility of spoken Danish, but also interacts significantly with reduction: Intelligibility of clearly articulated Danish only increases if the speech signal has a longer duration.

However, as there is evidence that preliterate Danish- and Swedish-speaking children decode the neighbouring language equally well (Schüppert & Gooskens 2012, 2011, 2010), it is likely that extra-linguistic factors interact with the different correlates of articulation rate. Findings reported by Schüppert, Ziegler, Borgström, Juul, Holmqvist & Gooskens (submitted), for instance, suggest that Danish-speaking listeners activate their L1 Danish orthography when confronted with spoken Swedish, which serves as an additional cue during spoken word recognition, because sounds that are found in spoken Swedish, but have been lenited or deleted in spoken Danish, are preserved in Danish orthography. Future research should investigate whether this effect is more pronounced for fast speech than for slow speech.

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