Explaining Danish-Swedish asymmetric word intelligibility - An error analysis

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Abstract

Previous research has shown that the Danish-Swedish mutual intelligibility is asymmetric at the text level. Danes perform better in tests developed to investigate intelligibility of Swedish at the global level of whole texts than Swedes participating in Danish tests. This asymmetry has usually been attributed to non-linguistic factors such as a more positive attitude towards Swedes and more experience with Swedish among Danes than vice versa. Also strong evidence has been found for general linguistic explanations of the asymmetry such as speech rate which has been measured to be higher in Danish than in Swedish. Also Danes seem to benefit from the fact that Swedish is similar to written Danish and Swedish when they listen to spoken Swedish. This benefit is smaller for Swedes because spoken Danish has developed away from its written Swedish and Danish form. In the present investigation we investigated Danish-Swedish mutual intelligibility at the word level. We also found an asymmetry at this level and therefore conclude that at least part of the explanation for the asymmetric Danish-Swedish intelligibility has to do with linguistic characteristics that are present in single words. To gain insight into the linguistic factors that cause this asymmetry we made a detailed analysis of the kind of errors that the listeners made when listening to cognate word pairs with asymmetric intelligibility. We focus on sound correspondences causing asymmetric problems.

1. Introduction

Some languages are so closely related that their speakers can communicate each using their own language. Research has shown that speakers of two closely related languages do not always understand each other to the same extent. Asymmetry has been observed between many language pairs, for example between Spanish and Portuguese (Jensen 1989), between Danish and Swedish (Gooskens, Van Heuven, Van Bezooijen & Pacilly 2010) and between Czech and Slovak (Budovicová 1987). In the literature (e.g. Börestam 1987, Bø 1978, Maurud 1976, Wolff 1959), attitudes are often held responsible for such asymmetrical results. It is assumed that if the attitudes of speakers of language A are more positive towards language B than the attitudes of speakers of language B towards language A, speakers of language A will also have fewer problems in understanding language B than speakers of language B will have in understanding language A. It is reasoned that a positive attitude will encourage the reader or listener to try and understand the language in question, whereas a negative attitude

will discourage the reader or listener from making an effort. However, an increasing amount of evidence suggests that linguistic factors may be part of the explanation for the asymmetric intelligibility between some language pairs.

Gooskens, Van Bezooijen & Van Heuven (accepted) presented 40 highly frequent Dutch and German cognate (i.e. historically related) nouns, recorded by a perfect bilingual speaker, to Dutch and German children between nine and twelve years in a word translation task. The German and Dutch children were comparable in that they did not know the other language or a related dialect and expressed equally positive attitudes towards the other language, its speakers and the country. It was thus ensured that language contact and language attitude could not play a role in the relative intelligibility. The results revealed that the Dutch listeners were significantly better at understanding German cognates (50.2% correct translations) than the German listeners were at understanding Dutch cognates (41.9%). So, another example of asymmetric intelligibility between closely related languages was found. Since the relevant extra-linguistic factors had been excluded, the asymmetry must have a linguistic basis. To gain insight into the relevant linguistic factors, a detailed analysis was made of the 16 cognate pairs with an asymmetry larger than 20%. The results showed that neighbours (lexical competitors), phonetic detail and asymmetric perceptions of corresponding sounds play a major role in the explanation of the asymmetry.

The present paper is concerned with Swedish-Danish mutual intelligibility. This is the best-documented case of asymmetric intelligibility in the literature. Results of intelligibility tests have repeatedly shown that Danes understand spoken Swedish better than Swedes understand Danish (Gooskens et al. 2010). These results are usually explained by extra-linguistic factors such as asymmetric attitudes towards the (speakers of the) languages involved and unequal experience with the languages. In fact, Danes have a more positive attitude towards Swedes and are more often confronted with Swedish through the media and on vacation than the other way around.

In addition to these non-linguistic explanations of asymmetry, strong evidence has been found for linguistic explanations of the asymmetric Danish-Swedish intelligibility. The fact that the asymmetry is not found in the intelligibility of written texts suggests that an explanation should be sought in aspects of pronunciation, or, more precisely, in the relationship between the written and the spoken form of the language. Spoken Swedish is close to both written Swedish and written Danish, while spoken

Danish has developed away from its written form and is therefore rather distant from both written Danish and Swedish. This means that Danes can understand spoken Swedish better because of its close similarity to written Danish, while Swedes get less help from written Swedish when listening to spoken Danish (Schüppert 2011, Doetjes & Gooskens 2009). Furthermore, measurements have shown that Danes speak faster (produce more phonetic syllables per second) than Swedes and leave out more syllables than Swedes in spontaneous speech (Schüppert, Gooskens, Hilton & Van Heuven 2012). This may also have a negative effect on the intelligibility of spoken Danish by Swedes compared to the intelligibility of spoken Swedish by Danes.

The asymmetry in the mutual intelligibility between Danish and Swedish has been assessed at the global level of whole spoken texts (e.g. Delsing & Lundin Åkesson 2005) and also the linguistic explanations for the asymmetry that have been proposed are rather general. In the present investigation we investigate Danish-Swedish mutual intelligibility at the word level. If an asymmetry is also found at this level, we can conclude that at least part of the explanation for the asymmetric Danish-Swedish intelligibility has to do with linguistic characteristics that are present in single words. We will employ the same method as used for the analysis of Dutch-German mutual word intelligibility discussed above (Gooskens et al. accepted). We will look at the errors made by speakers of Danish and Swedish when translating words from the neighbouring language into their own language. We will focus on the most regular errors in order to be able to draw general conclusions about the phonetic-phonological factors playing a role in Danish-Swedish intelligibility at the word level. If an asymmetry is found in the case of Danish-Swedish mutual intelligibility it is possible that lexical competitors play an important role as in the case of the Dutch-German word pairs. Also phonetic detail and asymmetric perceptions of corresponding sounds are likely to be involved, but the exact nature of these factors can be expected to differ, since the languages have different phoneme inventories.

Our research questions can be formulated as follows:

1. Is Danish-Swedish mutual intelligibility asymmetric at the word level?
2. If so, which word characteristics explain this asymmetry?

We will start out by providing relevant information about the Danish and Swedish sounds systems (Section 2). In Section 3 we describe the investigation set up to test the mutual word intelligibility of Danish and Swedish and we present the results. The results are explained by means of an error analysis which is presented in Section 4 and finally we draw some general conclusions in Section 5.

2. The Danish and Swedish sound systems

2.1 Danish

The Danish vowel system is complicated. There are a large number of vowel phonemes. In Figure 1 the 16 vowels that can be distinguished in stressed position are presented. In addition, [ə] and [ɐ] can occur in unstressed syllables. There is an even larger number of phonetic realizations of these vowels. Grønnum (2007: 19) distinguishes 40 different vowel sounds and an even larger number of allophones, for example depending on length or whether the vowel occurs before or after /r/. For example, /ø/ is lowered when it occurs either before or after /r/, and /a/ is pronounced as [æ] when it is long. With the exception of [a], [ʌ], [ə] and [ɐ] all vowels may be either long and short. In addition, long vowels may have *stød* (indicated by the symbol [’] in this paper). This is a special prosodic feature at the word level which does not occur in Swedish. It is pronounced as a kind of creaky voice and is found in long vowels and in voiced (sonorant) consonants. Presence versus absence of *stød* creates a number of minimal contrasts, for example [hɛn’ɔ] ‘hands’ versus [hɛnɔ] ‘happens’, both written as *hænder*.

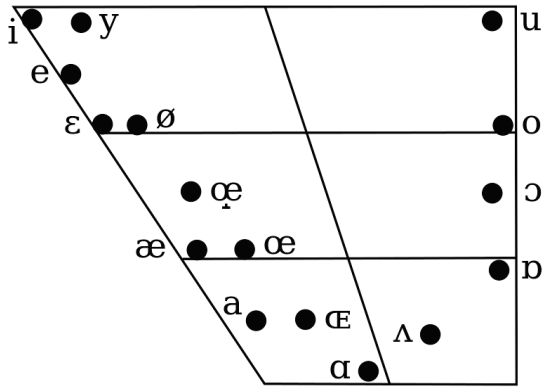

Figure 1: Danish vowels, from Grønnum (1998: 225)

The following 17 consonant phonemes are distinguished in Danish: /p t k b d g m n v f s h l r j/. In Figure 2, an overview is given of the phonetic realisations of Danish consonants./p, t, k/ are voiceless and aspirated (or affricated in the case of /t/) in syllable onset: [pʰ, tˢ, kʰ]. Some scholars (e.g. Grønnum 1998: 107, 263) analyse them as voiceless aspirated lenis: [b̥ʰ, d̥ˢ, g̊ʰ]. Aspiration is lost in syllable coda. /b, d, g/ are voiceless and lenis in syllable onset: [b̥, d̥, g̊]. In syllable coda /d, g/ and sometimes /b/ are weakened and become approximants, [o̯ ð̞ ɪ̯/o̯]. /g/ becomes [ɪ̯] after front vowels and [o̯] after back vowels. [ʊ, ʁ] may have slight frication, but they are usually pronounced as pure approximants. In syllable coda, /v/ and /r/ are normally pronounced [o̯] and [ɐ̯]. /r/ forms a diphthong with the preceding tautosyllabic vowel, e.g. *stor* 'big' [ˈsd̥oɐ̯ˀ], *næring* 'nourishment' [ˈnɛɐ̯eŋ]. /a(ː)r/ and /ɔ(ː)r/ coalesce into the long vowels [aː] and [ɒː] respectively. /ər/, /rə/ and /rər/ are all rendered as [ɐ], e.g. *læger* 'doctors', *lære* 'teach, learn; doctrine' and *lærer* 'teaches, learns; teacher' are all pronounced as [ˈlɛːɐ]. [ɕ] occurs only after /s/ or /t/. Since [j] does not occur after these phonemes, [ɕ] can be analyzed as /j/, which is devoiced after voiceless alveolar frication. This makes it unnecessary to postulate a /ɕ/-phoneme in Danish (Grønnum 2007: 118). The Danish sound [ð̞], a palatal non-lateral approximant written as *d* is a result of the weakening of Old Nordic /t/ which took place in Old Danish (1100-1525). Similar to the weakening of /d/ to [ð̞] in Danish, the /g/ has been weakened from Old Nordic /g/ resulting first in [ɣ] and then in [ɪ̯], [o̯] or even a deletion in positions where /g/ has been retained in Swedish.

	Bilabial		Labio-dental		Alve-olar		Alveolo-palatal		Palatal	Velar		Uvu-lar	Glot-tal
Nasal		m				n					ŋ		
Stop	pʰ	b̥			tˢ	d̥				kʰ	g̊		
Fricative			f		s		ɕ						h
Approxi-mant				ʋ o̯					ð̞ j ɪ̯			ʁ̞ ɐ̯	
Lateral Approxi-mant							l						

Figure 2: Danish consonants, from Grønnum (1998: 225)

In addition to the monophtongs, approximately 40 phonetic diphthongs are found in Danish. Grønnum (1998: 46) analyse these diphthongs as combinations of vowels and a consonants that can all be found as separate phonemes.

2.2 Swedish

Swedish has nine short and nine long vowels (see Figure 3). Length covaries with the quality of the vowels, with short variants being more centred and lax (Andersson 2002). No short vowels appear in open stressed syllables. The front vowels appear in rounded-unrounded pairs. /ɛː/, /ɛ/ (in stressed syllables), /øː/ (with a few exceptions), and /œ/ are lowered to [æː], [æ], [œ̝ː] and [œ̝], respectively, when preceding /r/. In many central and eastern areas of Sweden (including Stockholm), the contrast between /ɛ/ (written as *ä*) and /e/ (written as *e*) is lost, except before /r/. The loss of this contrast has the effect that *hetta* 'heat' and *hätta* 'cap' and possibly even *veta* 'know' and *väta* 'moisten' are pronounced in the same way. Long /ɑː/ is pronounced with a small amount of lip-rounding. The primary difference between the two high front rounded vowels /ʉː/ and /yː/ is that /ʉː/ is articulated with compressed lips, [ɪ^{β}], while /yː/ uses protruded lips, [i^{w}]. /uː/ is also compressed, [ɯ^{β}].

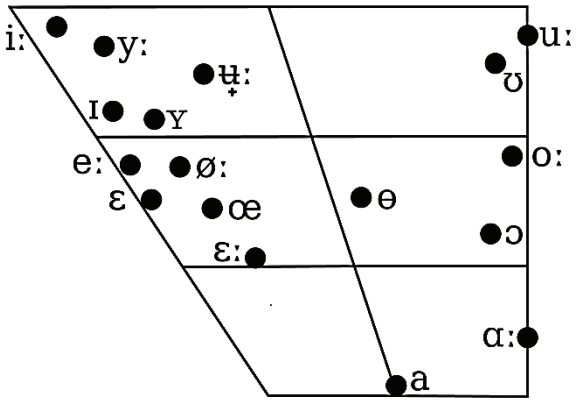

Figure 3: Swedish long and short vowels, from Engstrand (1999)

An overview of the 18 Swedish short consonant phonemes is given in Figure 4. A phonologically short consonant follows a long vowel (e.g. /viːt/) and a long consonant follows a short vowel (e.g. /vitː/) in stressed syllables. All segments are short in unstressed syllables. Initial fortis stops (/p, t, k/) are aspirated in stressed position, but unaspirated when

preceded by /s/ within the same morpheme. Hence *ko* 'cow' is pronounced [kʰuː] and *sko* 'shoe' is pronounced [skuː]. /ɕ/ is pronounced dorsally and /ɧ/ as a voiceless postalveolar-velar fricative. The combination of two such similar and rather unusual sounds as well as the large variety of partly overlapping allophones often presents difficulties for non-natives in telling the two apart. The existence of a third sibilant in the form of /s/ tends to confuse matters even more. /v/ and /j/ are pronounced with weak friction and they function phonotactically with the sonorants. /r/ has distinct variations in Standard Swedish. The realization as an alveolar trill occurs among most speakers only in contexts where emphatic stress is used. In Central Swedish, it is often pronounced as a fricative (transcribed as [ʐ]) or approximant (transcribed as [ɹ]). In most varieties of Swedish that use an alveolar /r/, the combination of /r/ with dental consonants (/t, d, n, l, s/) produces retroflex consonant realizations. Thus, *karta* /kɑːrta/ 'map' is realized as [kʰɑːʈa].

	Bilabial		Labio-dental		Dental		Alveolar/ Retroflex	Palatal		Velar		Glottal
Nasal	m				n					ŋ		
Stop	p	b			t	d				k	g	
Approximant				v			r		j			h
Fricative			f		s			ɕ		ɧ		
Trill												
Lateral					l							

Figure 4: Swedish consonants, from Engstrand (2004)

3. Intelligibility

3.1 Method

To test word intelligibility, an Internet-based experiment was conducted.[1] In this experiment, Danish listeners were confronted with 384 single

1 The experiment can be found on the Internet at http://www.let.rug.nl/lrs. It is possible to participate in the test with a guest account (login: germanic, password: guest). We thank Johan van der Geest for programming the experimental interface and databases.

Swedish nouns and Swedish listeners with the corresponding Danish nouns. These nouns were randomly selected from a list of 2575 highly frequent words.[2] In a pre-test, we assured that all these nouns were known to listeners from the test group, i.e. pupils aged 16 to 19.

The 384 words were read aloud by a male native Swedish speaker from the city of Uppsala north of Stockholm and a male native Danish speaker from Frederiksberg close to Copenhagen and recorded in a professional sound studio. Each listener heard one quarter, i.e. 96 of the 384 words in the neighbor language and was requested to write the translation into his native language into a text field within ten seconds. Prizes were promised to the participants, and especially to the best-scoring participants, to stimulate them to make an effort to do well. The choice of the words and the order of presentation were randomized in order to reduce tiredness effects. Since the word blocks were automatically assigned to the listeners in random order, some word blocks were presented to more listeners than others. The lowest number of listeners who heard a particular word block was seven, the highest number 19, with an average of 11 listeners both for the Danes and for the Swedes.

42 Swedish and 42 Danish secondary school pupils, aged 16 to 19, participated in the experiment. They were all mother tongue speakers of Danish or Swedish and grew up with no additional mother tongue. Since we are interested in intelligibility at a first confrontation, we needed listeners who had had little contact with the test language. We therefore only included listeners living in regions far from the Danish-Swedish border. As an extra precaution, we also had the listeners translate a number of non-cognates from the neighbor language, i.e. words that have no historical relationship. Such words should be unintelligible to listeners with no prior experience with the language. Indeed, hardly any of the non-cognates were recognized. An exception is formed by the word *flicka* 'girl' (Danish *pige*), which was translated correctly by 68 per cent of the Danish listeners. This word is probably known to most Danes as a stereotypical Swedish word. It was used for example in the popular Danish pop song *sköna flicka* 'beautiful girl' by Kim Larsen. On the basis of the generally low intelligibility of the non-cognates we decided not to exclude any of the listeners.

2 The list was prepared for investigating the intelligibility of several Germanic languages. It was based on the most frequent words occurring in large corpora of both formal language (Europarl, cf. http://www.statmt.org/europarl/) and informal language (Corpus of Spoken Dutch, cf. http://lands.let.kun.nl/cgn/home.htm).

The responses given by the listeners were automatically categorized as right or wrong through a pattern match with intended answers. Some listeners did not fill in a translation of some words. We considered these missing translations as incorrect translations. Those answers which were categorized as wrong were subsequently checked manually by a Danish mother tongue speaker. Responses which deviated from the intended responses due to a mere spelling error were counted as correct identifications. Spelling errors were objectively defined as instances where only one letter had been spelt wrongly without resulting in another existing word. So, for example the mistake in *ærende* (correct *ærinde*) 'errand' is considered a spelling mistake and was therefore counted as correct (only one wrong letter without resulting in another existing word), while *aske* (correct *æske* 'box') was not counted as correct because the mistake results in an existing word meaning 'ash'. Some Swedish words have more than one possible translation. For example the Swedish word *brist* 'lack' can be translated into Danish *brist* or *mangel*, both meaning 'lack'. Both translations were counted as correct. In the case of homonyms, both possible translations were accepted as correct. For example, Swedish *här* can be translated correctly into Danish *hær* 'army' or *her* 'here'.

After this procedure, we had obtained a score of zero (word not identified) or one (word identified) per word for each listener. We then calculated the percentages of correct translations per word in each language.

We only look at the errors made when translating the cognates since non-cognate forms should, almost by definition, be unrecognizable. Cognates are historically related word pairs that still bear the same meaning in both languages. We use a broad definition of cognates, including not only shared inherited words from Proto-Nordic such as Danish *fod*, Swedish *fot* 'foot', but also shared loans such as Swedish/Danish *perspektiv* 'perspective', which is borrowed from the same Latin source in both languages. Since the focus of our study is on sound correspondences rather than the on the morphological level, we also excluded words that have a cognate root but a derivational morpheme that differs between the corresponding cognates in Swedish and Danish. So, for example, the word pair Swedish *undersökning* Danish *undersøgelse* 'examination' was excluded from the analyses. Of the 384 nouns, 345 proved to be cognate Danish-Swedish nouns.

3.2 Results

The Danes translated 57.0% of the words correctly (61.8% when the non-cognates were excluded) and the Swedes translated 45.0% correctly (49.4% without non-cognates). The differences are significant at the 1% level (t = 5.694, df = 383 when all words are included and t = 6.066, df = 344 when non-cognates are excluded). This means that the first research question can be answered positively. Danish-Swedish mutual word intelligibility is asymmetric. So, asymmetry that has been found at the text level in previous research is also found at the word level. The difference is considerable: 12.0% for all words, and 12.4% for just the cognates.

To gain insight into possibly relevant linguistic factors explaining the asymmetry, we calculated the difference in intelligibility between the two listener groups separately for all cognate pairs. In Figure 5 quantitative data are presented for the 109 cognates that were better understood by the Swedish listeners than by the Danish listeners (left side of Figure 5) and the 194 cognates that were better understood by the Danish listeners than by the Swedish listeners (right side) as well as the 42 cognate pairs that yielded identical scores for the two listener groups (middle).

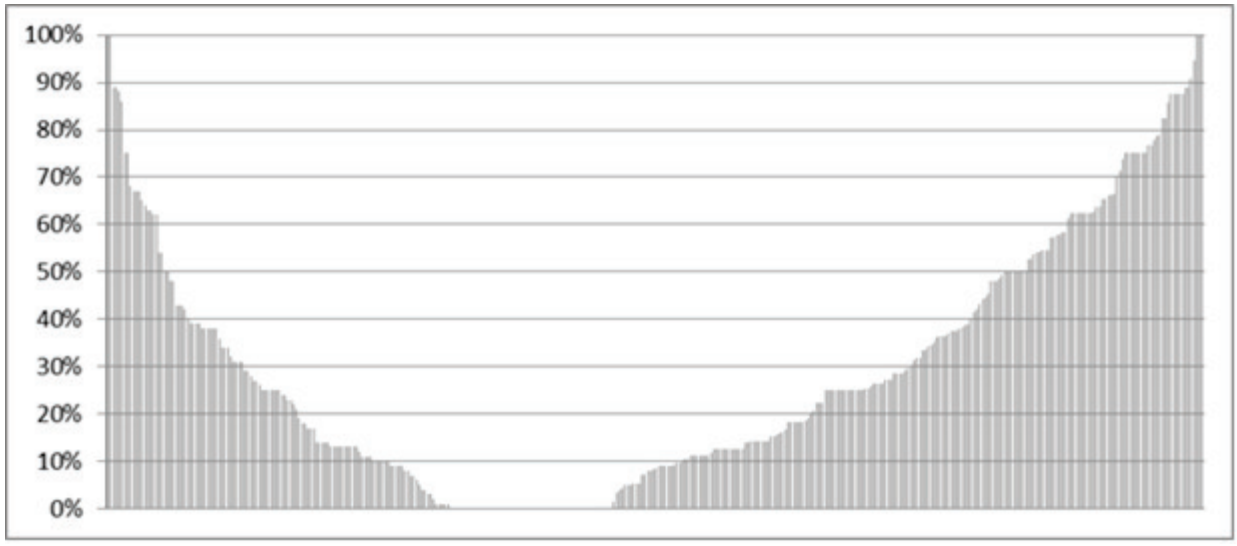

Figure 5: Number of cognates that were better understood by the Swedish listeners than by the Danish listeners (left) and cognates that were better understood by the Danish listeners than by the Swedish listeners (right). On the vertical axis the magnitude of the differences is expressed as the percentage of correct translations. On the horizontal axis the individual words are presented ordered from the words with the largest asymmetric intelligibility to the smallest asymmetric intelligibility (on the left) and from the smallest to the largest asymmetry (on the right).

In Table 1 we broke up the asymmetric intelligibility scores into five groups by presenting the numbers of cognates that have a large asymmetry (more than 80%) or smaller asymmetries (less than 80%, 60%, 40% and 20%) for the two listeners groups. Figure 5 and Table 1 make clear that the significant asymmetry in intelligibility in favour of the Danish listeners manifests itself at all levels. In general, there are more cognate pairs where the Danish listeners performed better than the other way around (in total 194 versus 109). Also, the number of cognate pairs with extreme asymmetric intelligibility is larger for the Danish listeners than for the Swedish listeners (14 versus 4 in the > 80% group and 32 versus 11 in the > 60% group).

Table 1: The number of cognate pairs in five groups of cognates with asymmetry in the percentages of correct translations. The results are presented separately for the two groups of listeners, from high asymmetry (81-100%) to low asymmetry (1-20%). For each of the ten subgroups two examples are given. For 42 pairs of cognates there was no asymmetry.

% asymmetry	Swedes translate more cognates correctly	Danes translate more cognates correctly
81-100	*N* = 4 Da. *luft* [lofd] Sw. *luft* [lɵft] 'air'	*N* = 14 Da. *jakke* [jɑgə] Sw. *jacka* 'jacket' [jakːa]
61-80	*N* = 11 Da. *projekt* [pʁoʃɛgd] Sw. *projekt* [prʊɧɛkt] 'project'	*N* = 32 *Da. fred* [fʁeˀð] Sw. *fred* [freːd] 'peace'
41-60	*N* = 10 Da. *april* [apʁiːˀl] Sw. *april* [aprɪlː] 'April'	*N* = 32 *Da. navn* [nɑʊˀn] Sw. *Namn* [namn] 'name'
21-40	*N* = 33 Da. *besvær* [besvɛːɐˀ] Sw. *besvär* [besvæːr] 'trouble'	*N* = 53 Da. *glæde* [glɛːðˀə] Sw. *glädja* [glɛːdja] 'happiness'
1-20	*N* = 51 Da. *køn* [køn'] Sw. *kön*[ɕøːn] 'gender'	*N* = 63 Da. *guide* [gɑːjd] Sw. *guide* [gajd] 'guide'
total	*N* = 109	*N* = 194

In order to gain insight into the nature of the linguistic factors determining the asymmetry in intelligibility between Danes and Swedes we made a detailed analysis of the erroneous responses for the cognate pairs with an asymmetry larger than 20%. In total there were 189 cases meeting this criterion. There were 131 cognates that caused more difficulties for the Swedes than for the Danes and 58 cognates that were less often translated correctly by the Danes than by the Swedes at the 20% level. There was a total of 590 Danish answers belonging to this subgroup of words, of which 188 were correct translations and 58 were missing responses. Of the total of 1403 Swedish answers, 381 were correct translations and 139 were missing responses. In total this left us with 344 errors made by the Danes and 883 errors made by the Swedes for further analysis.

4. Causes for asymmetry

We started out by calculating the percentages of different consonants and vowels between Swedish and Danish cognate words. To do this, we aligned the broad phonetic transcriptions of all cognate word pairs using the Levenshtein algorithm, matching vowels with vowels and consonants with consonants (Nerbonne & Heeringa 2010). Next we counted the total number of consonant differences and vowel differences. A sound missing in one of the languages also counted as a difference. We divided the total number of differences by the total numbers of sounds in the alignments and multiplied the outcome by 100. The results showed that 50.0% of the sounds were different, 25.4% of them being vowels and 24.6% of them being consonants.

However, these calculations only give us an impression of the relationship between pronunciation differences and percentages of correct translations. They do not contribute to our understanding of asymmetry since in principle pronunciation differences are symmetric: the difference between Swedish sound a and Danish sound b is the same as the difference between Danish sound b and Swedish sound a. Therefore we had a closer look at the kind of errors that the listeners made.

For each wrong translation we noted whether the erroneous response was due to a difference in the vowel quality in the two languages or to a difference in the consonant quality (or both). For example, when a Swedish listener translated the Danish word *stol* [sdoːˀl] ‘chair’ with Swedish *stål* [stoːl] ‘steel’ instead of the correct *stol* [stuːl] ‘chair’, this mistake is clearly caused by a difference in vowel quality. Similarly, when a Danish

listener translated the Swedish word *hamn* [hamn] 'harbour' into Danish *ham* [hɑm'] 'him' this must be due to the consonant cluster at the end of the word which is phonotactically non-existent in Danish. By having a close look at the errors made for the same words in both directions (Danish words translated by Swedes and Swedish words translated by Danes) we hope to get an impression of the causes underlying the asymmetry. It should be noted that in many cases the wrong translation is caused by a combination of more than one sound difference between the related words. And more differences may add to confusions for the listeners. For example, the fact that Swedish *choklad* [ɧɔklɑːd] 'chokolate' was translated incorrectly by many Danes into *forklar* [fɔklɑː'] 'explain' instead of the correct *chokolade* [ʃokolaːðə], probably has three causes (different consonants, different vowels and different number of syllables).

Furthermore, we only counted cases where it was completely clear which difference led to an error. In some cases it was not possible to deduce from the nature of the error why a particular translation mistake was made. For example, we do not understand why one listener translated the Danish word *indtryk* [entʁøg] 'impression' with Swedish *problem* [prʊbleːm] 'problem'. In some cases, it is obvious that the listener tried to match the test word with a similarly sounding word in his own language but not why he came up with a particular response. For example, a listener hearing Swedish *relation* [relaɧuːn] 'relation' translated it into Danish *delegation* [delegaɕoː'n] 'delegation' rather than the correct *relation* [ʁelaɕoː'n]. We have no indication why the listener made this mistake and therefore we did not place it into one of the categories. We do not aim – and do not think it is possible - to give a conclusive interpretation of each single error made, but we hope to be able to give a general impression of the kind of linguistic differences that led to confusions on the part of the listeners. The rest of the analysis will therefore have a more qualitative than quantitative character.

We first calculated the percentages of errors caused by vowel differences and by consonant differences. In the set of 132 words where Swedes made more mistakes than Danes (with an asymmetry of more than 20%), vowel differences seem to underlie the incorrect translation in 42.0% of the 883 analysed errors (i.e. excluding correct translations and missing responses) and consonant differences in 21.3% of the errors. In the set of 59 words where Danes made more mistakes than Swedes (also with an asymmetry of more than 20%) vowel differences resulted in an incorrect translation in 39.5% of the 344 analysed errors and consonant differences caused translation mistakes in 28.5% of the errors. So vowels seem to give

rise to more problems in word recognition than consonants for both groups of listeners.

In the next step we will have a close look at the kind of mistakes that the consonant and vowel differences cause. We discuss cases where the same consonant or vowel has caused an asymmetry of more than 20% in three or more words. An overview of sounds that fulfill these criteria is found in Table 2. Note that when interpreting the systematic errors, the historical relationships between the corresponding sounds of cognates are in principle irrelevant since lay listeners are mostly unfamiliar with syncronic language descriptions. We are interested in describing how listeners interpret synchronic sound differences.

Table 2: Consonants and vowel that cause an asymmetry of more than 20% in three or more Danish or Swedish words

Sounds causing asymmetry	Danish words	Swedish words
consonants	/d̥/, mute *d,* weakened /g/, /b,d,g/, /p,t,k/ (Section 4.1.1)	/ɕ/, /ɧ/ (Section 4.2.1)
vowels	/a/ in front position, /i/, /oː/, /u/ (Section 4.1.2)	/o/, /-ion/ (Section 4.2.2)

4.1 Consonants

4.1.1 Danish consonants as interpreted by Swedish listeners

Danish [d̥]

Danish [d̥] usually corresponds to a /t/ and sometimes to a /d/ in Swedish and caused many confusions on the part of the Swedish listeners because it is a non-existing sound in Swedish. All but one of the 25 words containing a [d̥] in the Danish word list were translated incorrectly more often by the Swedes than the corresponding Swedish words by the Danes (more than 20% asymmetry). The one exception is the Swedish word *choklad* [ɧɔklɑːd], Danish *chokolade* [ʃokolaːd̥ə] 'chocolate', which was difficult for Danes because of the special Swedish sound at the beginning of the word (see Section 4.1.2) and the different number of syllables of the cognates in the two languages. The Swedes tended to interpret the Danish sound as an /l/, probably due to its perceptual resemblance to this sound. [d̥] is characterized as a palatal by Grønnum (1998), but Basbøll (2005) categorizes it as

a an alveolar just like /l/. Grønnum (2007: 112) notes that because of the lack of friction, [ð̞] is often mistaken for an /l/ by many foreigners.

The Danes, on the other hand did not have any problems with the Swedish words with a /d/ in cases where the /d/ corresponds to the Danish [ð̞], because the [ð̞] is written as a *d* in the Danish orthography (our database contained no cases of a correspondence with Swedish /t/). We know from previous research that Danish listeners do indeed make use of their native orthography when confronted with Swedish cognates (Schüppert et al. submitted). An example of a Danish word containing [ð̞] which caused difficulties for the Swedish listeners is the Danish word *fod* [foːˀð̞] 'foot' that none of the 11 Swedish listeners translated correctly to *fot* [fuːt]. Six of the listeners translated the word into Swedish *full* [fɵlː] 'full' and the remaining five listeners translated it into some other word containing /l(ː)/. Sometimes the Swedes just ignored the [ð̞] and translated a Danish word containing the sound into Swedish words that sound like the word without the /d/. For example Danish *måned* [moːnəð̞] 'month' was translated into Swedish *måne* [moːnə] 'moon' instead of the correct *månad* [moːnad] by eight out of the 14 listeners.

Danish mute d

In many Danish words the /d/ is present in the orthography but it is not pronounced, the so-called mute *d*. This is often the case at the end of a word after /l/, /n/ or /r/, for example in *told* [tɔlˀ] 'customs', *blind* [blenˀ] 'blind' and *bord* [boːˀe̯] 'table' and sometimes before /s/ and /t/, for example in *slids* [slis] 'slit' and *lidt* [led] 'little'. Since in Swedish the /d/ is pronounced in the corresponding words, this mute *d* gives rise to many mistranslations by the Swedes. There are 20 Danish-Swedish word pairs involving the Danish mute *d* and in 19 cases mute *d* leads to a lower percentage correct on the part of the Swedish listeners. The largest asymmetry was found for the Danish word *bord* [boːˀe̯] 'table' that was translated correctly by none of the eight Swedish listeners who translated this word. Five listeners translated it into *bår* [boːr] 'stretcher'. The Danish listeners on the other hand did not experience any problems with the corresponding Swedish cognates. This may lead to the conclusion that a missing sound is more detrimental to intelligibility than an extra sound. However, it is more likely that the asymmetry should be explained by orthography like in the case of the [ð̞]-sound (see above). The mute *d* is present in Danish orthography and therefore the Danish listeners were not confused by the extra sound they heard. The Swedes on the other hand missed the

/d/ when they heard the Danish word and got no help from their orthography.

In one case the Swedes translated a word with a mute *d* in Danish better than the Danes translated the corresponding Swedish word. The word for 'stick' Swedish *pinne* [pɪnːə] Danish *pind* [pen] was translated correctly by five of the nine Swedes but only by one of the eight Danes. This word has a mute *d* in Danish but no /d/ in Swedish. In addition to the confusion caused by the mute *d* it also was confusing to the Danes that Swedish *pinne* has more syllables than the corresponding Danish word *pind*. Most of the Danes translated it with a bisyllabic word such as *hende* 'she'. It seems reasonable to assume that a different number of syllables in the corresponding word in the neighbouring language will cause confusion, but the Swedes seem to have fewer problems with the fact that the Danish word has fewer syllables. In addition to Swedish *pinne* versus Danish *pind* there are two other examples in our corpus where a Swedish word has more syllables than the corresponding cognate in Danish. One of the words was better understood by the Danes and one was better understood by the Swedes. There are more cases, 14 in total, where Danish has an extra syllable compared to the Swedish counterpart. Nine of these cognates were understood less well by the Swedes than by the Danes and five were better understood by the Swedes. It looks again as if an extra syllable is confusing for the listener and especially for the Swedes, maybe because they are less used to sounds and syllables being deleted while this happens frequently in Danish (Hilton, Schüppert & Gooskens 2011). So when a Dane heard the Swedish word *grupp* [grɵpː] 'group' it was not confusing to him that it has one syllable less than the corresponding Danish word *gruppe* [gʁubə] because this is actually how this word would be pronounced in normal or fast speech in Danish.

Danish weakened /g/

As explained in Section 2, the /g/ has been weakened from Old Nordic /g/ resulting in [ɪ̯], [ʊ̯] or even a deletion in positions where /g/ has been retained in Swedish. This has consequenses for the present-day interpretation of Danish words with sounds corresponding to Swedish /g/. An example is the Danish word *overvågning* [ɔʊ̯ɔvoːʊ̯neŋ] 'surveillance' which was translated correctly by none of the 14 Swedish listeners who listened to this word. They translated *overvågning* by words containing no /g/ such as *övervåning* [øːvərvoːnɪŋ] 'upper floor' (five times). There are nine Danish words with a weakened /g/ in our investigation of which eight

were less often correctly translated by the Swedish listeners. Again, the asymmetry in these words can be attributed to the Swedish /g/ being recognized from the orthography by the Danes while the Danish pronunciation causes confusions for the Swedish that cannot be solved by the Swedish orthography.

Danish /b, d, g/

The Danish consonants /b, d, g/ were often mistaken for Swedish voiced consonants /p, t, k/ in non-initial positions in the word. For example the Danish word *model* [mɔdɛl] 'model' was translated into *motell* [mɔtɛlː] 'motel' (or *hotell* [hɔtɛlː] 'hotel') by nine of the 14 Swedish listeners. The Danish plosives /b, d, g/ are in fact pronounced without voicing like /p, t, k/ while there is a voicing contrast in Swedish.[3] This may explain why the Swedes confused the two series of sounds. The Danes seem to have fewer problems with the Swedish pronunciations of /b, d, g/, probably because there is a clear voicing of these consonants that they may recognize from other languages that they know, such as English.

Danish /p, t, k/

Danish /p, t, k/ are written as *pp, tt, kk* in medial position after short vowels and they are pronounced in the same way as the lenis sounds /b, d, g/, without aspiration and voicing. So the intervocalic stop contrast between /p, t, k/ and /b, d, g/ is not present in Danish, whereas in Swedish there is a voicing contrast. Swedish /p, t, k/ are written as *pp, tt, ck* in Swedish and pronounced as long voiceless consonants. The Danish sounds caused problems in word recognition by the Swedes. The Danish /p, t, k/ consonants in medial position were perceived as voiced by the Swedes. There are 12 words with these consonants of which nine were more often correctly translated by the Danes, one was more often correctly translated by the Swedes and two showed no asymmetry. For example Danish *klokke* [klɔgə] 'clock' was only translated correctly by four of the 14 listeners into Swedish *klocka* [klɔkːa]. Of the remaining listeners seven translated it into *klaga* [klɑːga] 'complain'. The same results were found by Van Ommen, Hendriks, Gilbers, Van Heuven & Gooskens (submitted), who explain their

3 The only difference between the two series of consonants in Danish is aspiration (or affrication in the case of /t/), but this aspiration is lost in coda position and is therefore irrelevant for the distinction between words with /p, t, k/ in non-initial positions in the word.

results by the fact that the intensity of both Danish /p, t, k/ and /b, d, g/ is comparable to the intensity of the voice bar of Swedish /b, d, g/. Furthermore, since Swedish medial consonants also have a lengthening contrast a short consonant was often perceived by the Swedes where it actually corresponds to a long consonant in Swedish.

4.1.2 Swedish consonants as interpreted by Danish listeners

The only consonant that systematically lead to translation confusions among the Danish listeners is the Swedish velar fricative [ɧ], which does not exist in Danish. In our material this sound corresponds to Danish [ɕ] in five Swedish words (*pension* [paŋɧʉːn] 'pension', *projekt* [prʊɧɛkt] 'project', *lektion* [lɛkɧʉːn] 'lesson', *aktion* [akɧʉːn] 'action', *choklad* [ɧɔklɑːd] 'chocolate') and to Danish [sd] in the onset of the Swedish word *stjärna* [ɧæːɳa] 'star'. It was confused with various sounds by the Danes, but especially the fricative character of the sound is reflected in their translations. For example Swedish *choklad* [ɧɔklɑːd] with a [ɧ] at the word onset was translated by some form of Danish *forklare* [fɔklaːˀa] 'explain' by all 19 Danish listeners, for example *forklar* [fɔklaːˀ] (imperative), *forklare* [fɔklaːˀa] (present tense) or *forklaret* [fɔklaːˀað̩] (present participle). The Swedes might have had fewer problems with the Danish pronunciation [ɕ], which corresponds to the Swedish [ɧ]-sound because they recognize the pronunciation from English for example in *lection* and *pension*.

4.2. Vowels

4.2.1 Danish vowels as interpreted by Swedish listeners

Danish /a/ in front position

The most confusing vowel for Swedes listening to Danish was the /a/ in contexts without an *r*. A comparison of the Danish and the Swedish vowel charts in Figures 1 and 2 makes clear that the situation is complicated. In Swedish the vowel is pronounced in the back of the mouth, the short vowel as a mid-low back vowel [a] and the long vowel as a low back vowel with slight rounding [ɑ]. In Danish this phoneme is pronounced as a low front vowel [a] or as a near open front vowel [æ] except in a number of cases, especially after an /r/, where it is pronounced as a mid vowel [ɑ]. It is confusing that the Danish front vowel [a] is transcribed in the same way as the Swedish short back vowel in the literature. The Danish pronunciations

of the /a/ vowel in front position is close to the Swedish written *ä* which is pronounced as [ɛ] or [ɛː]. This is clearly reflected in the answers given by the listeners. For example the Danish word *flaske* [flasgə] 'bottle' (with a front vowel) was translated into Swedish *fläsk* [flɛsk] 'pork' by seven of the 14 Swedish listeners and correctly into Swedish *flaska* [flaska] (with a back vowel) by only three listeners. Danes on the other hand did not have real difficulties interpreting the Swedish /a/. There are 66 words containing a Danish /a/ pronounced as a front vowel. In 34 (52%) of these cases there was an asymmetry in intelligibility of more than 20% in favor of the Danish listeners, in 12 cases (18%) there was an asymmetry of less than 20% and in only 30% Danes had more difficulty with the Swedish words than the other way round. In these cases the difficulties do not seem to be due to the pronunciation of the /a/ but mainly to some other difficulty. For a Dane it is probably not confusing that a Swedish /a/ pronounced in the back of the mouth corresponds to the fronted Danish pronunciation because a Danish /a/ is in fact often pronounced in the back of the mouth like in Swedish (51 cases in our material). For example, the Danish *fad* [faˀð] 'dish' is pronounced with the front vowel [a] and *far* [fɑː] 'dad' is pronounced with the back vowel [ɑ].

Danish /i/

The second most confusing Danish vowel for Swedes is the Danish short /i/. This vowel is mostly pronounced as a close front vowel [i] in Danish, but sometimes it is pronounced as [e] or [ɛ]. The corresponding vowel is somewhere in between in Swedish, where it is pronounced as [ɪ]. In many cases the Swedes interpreted the open pronunciation of the Danish /i/ as an /e/ or an /ä/ and translated the Danish words into a Swedish word containing an /e/ or an /ä/. Examples are Danish *ring* [ʁɛŋ] 'ring' which was translated into *regn* [rɛŋn] 'rain' by seven Swedish listeners and correctly by only three and Danish *ting* [teŋ] 'thing' pronounced with [e], which is translated into Swedish *tänk* [tɛŋk] 'think' by four of the nine listeners. There are ten words in our material where it is clear that the open pronunciation of the Danish /i/ caused an asymmetry in favor of the Danes. The corresponding Swedish words caused fewer problems for the Danes, probably because they are used to the vowel /i/ having both an *i*-like and an *e*-like pronunciation and because the Swedish pronunciation is somewhere in between the two possible Danish pronunciations.

Danish /o:/

The long vowel written as *o* in Danish is pronounced as a close-mid vowel [o] and the corresponding Swedish vowel is pronounced as [u:]. This resulted in asymmetric intelligibility in four words because the Danish sound was interpreted as the sound written as *å* and pronounced as [o:] by the Swedish listeners. For example Danish *blod* [blo:ð̩] 'blood' was interpreted as Swedish *blå* [blo:] 'blue'. Only one of the eleven Swedish listeners translated this word correctly. The Danes could be expected to confuse the Swedish pronunciation of the *o* with a /u/ but this was not the case. We do not have an explanation for this. There are 19 words with Danish [o:] corresponding to Swedish [u:]. In 12 cases the Danes translated the words correctly more often than the Swedes, in four cases the asymmetry was below 20% and in three cases the Swedes translated more words correctly than the Danes.

Danish /u/

The Danish vowel /u/ is pronounced as a close back rounded vowel both when it is long and when it is short. The Swedish equivalents have much more fronted articulations, the long vowel is a high front rounded [ʉ:] and the short vowel has a centralized mid-high pronunciation [ʊ]. In many words, Swedish listeners confused the Danish vowel with the Swedish /o/ that has a pronunciation close to the Danish /u/. For example the Danish word *mur* [mu:'ɐ̯] 'wall' was interpreted as Swedish *mor* [mu:r] 'mother' by all eight Swedish listeners instead of the correct *mur* [mʉ:r]. Fifteen words with Danish /u/ were translated correctly more often by the Danish listeners than by the Swedish listeners, while nine words were translated correctly more often by Swedish listeners.

4.2.2 Swedish vowels as interpreted by Danish listeners

There are only two systematic confusions (three or more words) involving vowels in the case of the Danish listeners.

Swedish words ending in -ion

There are four loan words in our corpus ending with *–ion.* The /o/ in this ending is pronounced with [u:] in Swedish and with [o:] in Danish. Apparently, the Danes tried to find translations that contain a [u:], which leads to a variety of responses. For example Swedish *aktion* [akɧu:n] 'action' is

translated by *vakuum* [vaːˈkuom] 'vacuum' by four Danes instead of the correct *aktion* [ɑgɕoːˈn]. It is not clear why the Danes only seemed to have problems with the Swedish /o/ in this particular morpheme and why Swedes had fewer problems with the corresponding Danish pronunciation of this morpheme.

Swedish /ɵ/

The other sound which was systematically confused by the Danes is the Swedish /ɵ/ a mid-central rounded vowel. The Danes interpreted this sound as an /y/ or an /ø/ even though these sounds are more fronted. So the Swedish word *luft* [lɵft] 'air' was translated into *løft* [løfd] 'lift' by seven of the eight Danish listeners instead of the correct Danish *luft* [lʊfd], and Swedish *frukt* [frɵkt] 'fruit' was translated into Danish *frygt* [fʁøgd] 'fear' by five of the eight listeners while only one listener translated the word correctly into Danish *frugt* [fʁʊgd]. It seems that the rounding of the Swedish vowel was important in the perception of the Danes so that they chose Danish words with rounded vowels.

5. Conclusions

We set out to investigate the asymmetric intelligibility between Danish and Swedish that has often been assessed at the text level, Danes understanding Swedish better than the other way round. In our study we found that the same asymmetry manifests itself at the word level. Danish secondary school pupils translated 57.0% of 344 frequent Swedish words correctly while Swedish pupils only translated 45.0% of the corresponding Danish cognates correctly. There were more cognate pairs where the Danish listeners performed better than the Swedes, and the number of cognate pairs with an extreme degree of asymmetry was larger for the Danish listeners than for the Swedish listeners.

To gain insight into the linguistic factors underlying the asymmetry we carried out an error analysis. We wanted to find out which were the most frequent mistakes caused by differences in consonants and vowels in corresponding cognates in the two languages. Our results show that there were more specific Danish vowels and consonants that caused an asymmetric intelligibility in a consistent way, i.e. in three or more words, for the Swedes than for the Danes. Swedes had difficulties with the Danish plosives and with the weakened forms of /d/ and /g/. As far as vowels are concerned most translation errors were found for Danish words with /a/,

/i/, /o/ and /u/. The Danish listeners had difficulty with Swedish words containing the [ɧ]-sound, which is not part of the Danish sound system and with the vowels /o/ and with /u/ in words ending in /-ion/.

When having a closer look at the wrong translations, two general observations can be made. First, it seems that orthography plays an important role in the explanation of the asymmetric word intelligibility. Often the Danish listeners could translate a Swedish word correctly in spite of a sound difference with the corresponding Danish cognate because of a similarity between the Swedish pronunciation and the Danish orthographic representation. This situation hardly occurred in the case of Swedes listening to Danish words. So apparently the degree to which listeners find support in the orthography to interpret auditory stimuli differs between the two languages. This confirms the results found by Schüppert (2011). The explanation can be found in the fact that the Danish pronunciation has changed very fast during the past decades (Grønnum 1998, Brink & Lund 1975) while this is less the case for the Swedish pronunciation. Both the Danish and the Swedish orthographies are rather conservative reflecting a previous stage of the two languages. As a result Swedish pronunciation is more similar to the Danish orthography than vice versa.

A second observation is that neighbour words seem to play an important role in the asymmetric word intelligibility. When listeners hear a word in a closely related language they will try to match it with the word that sounds most similar in their own language. Sometimes this word is the corresponding cognate, but in many cases another, non-related word is just as similar or even more similar. This is largely a matter of chance and related to particular sound developments in the languages at hand. In some cases a word in the native language is even more similar to the word in the related language than the cognate word. For example the Danish word *faster* [fasdɔ] 'aunt' was translated by *fester* [fɛstər] 'parties' by most Swedish listeners because the *a*-sound was perceived as an *e*-sound by the Swedes. Such words are often referred to as 'neighbours'. Since the neighbours are similar or even identical to the stimulus word they serve as competing responses. For an extensive description of the neighbourhood activation model, see Luce & Pisoni (1998). Since a high neighbourhood density enlarges the number of possible candidates for translation, we assume that the higher the density is, the lower the number of correct identifications will be. This holds especially for a communication situation where the listener has no linguistic or extra-linguistic context information which may help to disambiguate the meaning of the stimulus word. Of course when hearing single words, as in the present study, the chance for a

semantically and linguistically unrelated neighbour to emerge as a response is considerable.

Sometimes the listeners seem to have been confused by neighbours in another language such as English or German. An example where another language interferes is Swedish *här* [hæːr] 'here' that was often translated into Danish *hår* [hɒː'] 'hair' instead of *her* [heːɐ̯] because of the phonetic similarity to English *hair* [heəʳ] in spite of the similar pronunciations in Swedish and Danish. Another example is Danish *aske* [asgə] 'ash', which was translated into *fråga* 'question' by many Swedes because of the similarity of the Danish word to American English *ask* [æsk]. When counting the number of cases where the listeners translated a word via a third language we found that both the Danes and the Swedes do this in 2% of the cases. So this cannot be part of the explanation for the asymmetry. Swedish listeners were not to a higher degree in the 'foreign language mode' when listening to Danish than the Danes when listening to Swedish.

In conclusion, the results of our investigation show similar results as the investigation by Gooskens et al. (accepted) on the mutual intelligibility of Dutch and German. They found lexical neighbours, phonetic detail and asymmetric perception of corresponding sounds to play a major role in the explanation of asymmetry. In addition to these factors we showed that orthography also plays an important role in explaining the asymmetry between Swedish and Danish.

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