Phonetic and lexical predictors of intelligibility of Scandinavian varieties.

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outline

> background
> material / method
> intelligibility
> phonetic distance
> lexical distance
> correlations / regression analyses
> conclusions
background

> aggregate phonetic distance successful predictor of intelligibility of standard Scandinavian languages, \( r = -0.82 \) and \( p < 0.01 \), (Gooskens 2007).

> phonetic distance has not been split up for vowels and consonants / phonetic sublevels with regard to intelligibility.

> lexical distance is another influential factor in intelligibility.
research question 1

> What is the relative contribution of (full) phonetic distance and lexical distance to intelligibility?
research question 2

> What is the relative contribution of consonant distances and vowel distances to intelligibility?
research question 3

> What is the relative contribution of substitution, insertion, deletion, lengthening and shortening of both vowels and consonants to intelligibility?
intelligibility and linguistic distances

- **lexical distance**
  - **consonants**
    - sub.
    - ins.
    - del.
    - len.
    - sh.

- **phonetic distance**
  - **vowels**
    - sub.
    - ins.
    - del.
    - len.
    - sh.
consonants vs vowels

> consonants are more important for the semantic identity of a word than vowels; they function as reference points in words.

> word recognition in English depends more on correct consonant identification than on the correct identification of vowels (Van Ooijen 1994 and references).
Ashby and Maidment (2005)

Mary has a little lamb.

- replace all vowels by [3ː]:
  M3ːr3ː h3ːs 3ː l3ːttl3ː l3ːmb.

- replace all consonants by [d]:
  Dady dad a diddde dadd.
hypothesis

> the occurrence of deviant segments in the consonantal structure of a word is more disturbing for intelligibility than changes in the vowel of a word.
material

> *The North Wind and the Sun.*

- well-known text in phonetic research.

- recordings and transcriptions in 18 Scandinavian language varieties.

- average of 98 words.
8 Norwegian varieties
Standard Swedish (Stockholm) + 3 Swedish dialects
Standard Danish (Lyngby) + 3 Danish dialects
Finland Swedish (Helsinki)
Faroese (Torshavn)
material

> The Scandinavian languages and dialects.

- closely related language varieties.

- Standard Mainland Scandinavian languages are mutually intelligible.

- little research on dialect intelligibility in Scandinavia.
intelligibility experiment

- how intelligible are the 18 Scandinavian language varieties for speakers of Standard Danish?

- **listening experiment** on the basis of recordings of the fable *The North Wind and the Sun* in all Scandinavian varieties.

- **test:** 6 sentences of the fable in 6 different varieties (random order), e.g. sentence 3 Tromsø, sentence 5 Lidköping, sentence 2 Oslo, etc.
intelligibility experiment

- **listeners**: 351 high school pupils from Copenhagen, aged between 15 and 20 (average 17.6).

- **task**: translate the spoken text into Standard Danish.

- **intelligibility score** = percentage of correctly translated words.
phonetic distance

> transcriptions of the fable *The North Wind and the Sun* in all Scandinavian varieties.

> cognate wordpairs between Standard Danish and each of the other varieties.

> Levenshtein algorithm.
Levenshtein algorithm

> 5 operations to change a pronunciation in one variety into a corresponding pronunciation in another variety:

- substitution
- insertion
- deletion
- lengthening
- shortening
# Levenshtein algorithm

Standard DA [ʔeːni] versus Standard SE [eːnɪɡa]  
‘in agreement’

<table>
<thead>
<tr>
<th>Standard DA</th>
<th>?eni</th>
<th>delete ?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>eni</td>
<td>substitute i by ɪ</td>
<td></td>
</tr>
<tr>
<td></td>
<td>enɪ</td>
<td>insert g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>enɪɡ</td>
<td>insert a</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard SE</th>
<th>enɪɡa</th>
<th></th>
</tr>
</thead>
</table>
Levenshtein algorithm

divide total number of operations by length of alignment:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard DA</td>
<td>?</td>
<td>e</td>
<td>n</td>
<td>i</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard SE</td>
<td>e</td>
<td>n</td>
<td>i</td>
<td>g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

phonetic distance: 4/6 = 0.67 or 67%
Levenshtein algorithm

> many different versions (cf. Heeringa 2004).

> present study:
- gradual segment distances.
- spectogram distances on the basis of IPA samples.
- e.g. the distance between [a] and [a] is smaller than between [a] and [i].
Levenshtein algorithm

> full phonetic distances [all speech segments].

> consonant / vowel distance: sum of all consonant / vowel sublevels.

> phonetic sublevel distance (e.g. consonant substitution): total number of consonant substitutions/length of alignment.

> the larger the phonetic distance, the less intelligible another Scandinavian variety will be for a speaker of Standard Danish.
lexical distance

> percentage of non-cognates words between
  Standard Danish and each of the other varieties.

> the larger the lexical distance, the less intelligible
  another Scandinavian variety will be for a speaker
  of Standard Danish.
research question 1

> What is the relative contribution of (full) phonetic distance and lexical distance to intelligibility?
full phonetic distance and intelligibility

$r = -0.86$ and $p < 0.01$
lexical distance and intelligibility
\[ r = -0.64 \text{ and } p < 0.01 \]
<table>
<thead>
<tr>
<th>linguistic distance</th>
<th>intelligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>full phonetic distance</td>
<td>-.86**</td>
</tr>
<tr>
<td>lexical distance</td>
<td>-.64**</td>
</tr>
<tr>
<td>full phonetic distance + lexical distance</td>
<td>-.90**</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed)

Stepwise regression analysis excludes: lexical distance
research question 2

> What is the relative contribution of consonant distances and vowel distances to intelligibility?
<table>
<thead>
<tr>
<th>phonetic distance</th>
<th>intelligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>vowel distances</td>
<td>-.65**</td>
</tr>
<tr>
<td>consonant distances</td>
<td>-.67**</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed)
research question 3

> What is the relative contribution of substitution, insertion, deletion, lengthening and shortening of both vowels and consonants to intelligibility?
<table>
<thead>
<tr>
<th>phonetic distance</th>
<th>intelligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>vowel substitution</td>
<td>.11</td>
</tr>
<tr>
<td>vowel insertion</td>
<td>-.39</td>
</tr>
<tr>
<td>vowel deletion</td>
<td>-.44</td>
</tr>
<tr>
<td>vowel lengthening</td>
<td>-.42</td>
</tr>
<tr>
<td>vowel shortening</td>
<td>-.49*</td>
</tr>
</tbody>
</table>

*.Correlation is significant at the 0.05 level (2-tailed)
<table>
<thead>
<tr>
<th>phonetic distance</th>
<th>intelligibility</th>
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</thead>
<tbody>
<tr>
<td>consonant substitution</td>
<td>-.57*</td>
</tr>
<tr>
<td>consonant insertion</td>
<td>-.20</td>
</tr>
<tr>
<td>consonant deletion</td>
<td>-.22</td>
</tr>
<tr>
<td>consonant lengthening</td>
<td>.07</td>
</tr>
<tr>
<td>consonant shortening</td>
<td>-.22</td>
</tr>
</tbody>
</table>

*.Correlation is significant at the 0.05 level (2-tailed)
regression analyses

<table>
<thead>
<tr>
<th>Method</th>
<th>entered variables</th>
<th>model</th>
<th>significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>all phonetic sublevels</td>
<td>all phonetic sublevels</td>
<td>$r = .93$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$p = .050$</td>
</tr>
<tr>
<td>Rowwise</td>
<td>all phonetic sublevels</td>
<td>consonant sub., vowel ins., vowel</td>
<td>$r = .87$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>short.</td>
<td>$p = .000$</td>
</tr>
</tbody>
</table>
conclusions

> full phonetic distance is a good predictor of intelligibility: 
  \( r = -0.86^{**} \)

> lexical distance is a moderately good predictor of intelligibility: \( r = -0.64^{**} \)

> the relative contribution of consonant distances and vowel distances to intelligibility is about equal: 
  \( r = -0.67^{**} \) versus \( r = -0.65^{**} \)
conclusions

> consonant substitutions:
  - change in reference points of a word.  \( r = -0.57^* \)

> vowel shortening:
  - loss of information about the vowel (quantity);
    vowel length is phonemically distinctive.  \( r = -0.49^* \)

> vowel insertion:
  - insertions change syllable structure / may
    result in diphthongs.  \( r = -0.39 \)
Thank you for your attention