An Acoustic Analysis of Vowel Pronunciation in Swedish Dialects
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Chapter 6

Analysis on the variable level

In Chapter 5 a method for assessing vowel quality from acoustic speech samples by means of principal components (PCs) of Bark filtered vowel spectra was described. In the present chapter the described acoustic method is used for analyzing dialectal variation in Swedish vowel pronunciation. The variation in the acoustic variables of the 19 vowels described in § 4.2 is analyzed. Throughout this chapter the data is divided into two speaker groups per site: older and younger speakers. Each group includes approximately six speakers—three men and three women (see § 4.3). The arithmetic means of the speakers in the two speaker groups per site were calculated for PC1 and PC2 for each vowel (see the lowest part of Figure 5.12 on p. 72) and form the basis for all analyses presented in this chapter.

A first impression of the variation is obtained by plotting the vowel data in the PC2/PC1 plane. Figure 6.1 displays one standard deviation ellipses\(^1\) of the 19 Swedish vowels in the PC space. The data for drawing the ellipses comprised the average PC values in both speaker groups at each site measured at the temporal midpoint of the vowel segments. By using average values per speaker group for drawing the ellipses, the individual variation within the groups has been filtered out, and the ellipses show the amount of linguistic variation across sites and across the two age groups. The graphs gives an idea about the average position of each vowel in the PC space. The size and orientation of the ellipses indicate the amount of variation in each vowel and the main direction of the variation. For example, the vowel in \textit{dör} has the largest ellipse, which means that this is the most variable vowel across sites and across the two generations. From the orientation of the ellipses we can see that, for example, the vowel in \textit{nät} varies more on the PC1 values than on PC2, while the vowel in \textit{lus} varies more on PC2. Overlapping ellipses indicate that the pronunciation of the different vowels show a considerable amount of overlap across varieties.

\(^1\) Ellipses are drawn by applying PCA separately for each vowel with the acoustic PCs as input variables (Harrington, 2010, Ch. 6). The major and minor axes of the ellipses are the two first PCs of the data and the longest axis, hence, shows the direction that explains most of the variance.
Chapter 6. Analysis on the variable level

In § 6.1, the variation across sites and across the two generations in each vowel is described.

In § 6.2, the amount of variation per vowel is quantified, and the vowels are compared to each other based on the amount of variation across sites (§ 6.2.1), and across the two age groups (§ 6.2.2). The results show which of the vowels vary the most geographically and which vowels are changing in apparent time.

A factor analysis was carried out in order to identify vowels with similar distribution patterns. The results are presented in § 6.3. The factor analysis showed co-occurrence of a number of vowel features. Each extracted factor corresponds to a distinct geographic and/or generational distribution pattern in the data. By visualizing the factor scores on maps these distribution patterns were identified.

In § 6.4 the results obtained by the different analyses in §§ 6.1, 6.2 and 6.3 are compared and summarized. The Swedish place names and area names used in the text are found in the maps in Figures 2.1, 2.2 and 4.1.

6.1 Variation per vowel

In order to get an idea of the pronunciation and geographical variation of the 19 different vowels in the data set, maps visualizing the PC values of each vowel were created. The maps are found in Appendix C. In these maps the two extracted PCs (see Chapter 5) are visualized by means of a two-dimensional color spectrum (Figure B.2, p. 211). In Appendix B (§ B.2) the assignment and interpretation of the colors are explained in more detail.

The acoustic analysis of the vowels was made at nine temporal points in every vowel segment in order to include as much information as possible about formant movements. For displaying the results of each vowel, however, only the first and the last sampling point were chosen, which taken together should give an indication of the overall vowel quality. The maps show the pronunciation as measured near onset (at 25% of the vowel duration) and near offset (75%). For each site in the data set, the average vowel quality of the older speakers and the younger speakers is visualized separately. The maps give an overview of the variation across sites and across the two generations for each vowel. The values close to onset give an indication of the basic vowel quality, while the degree of diphthongization can be studied by comparing the PC values measured close to onset of the vowels with the values close to offset. For comparison, a Standard Swedish reference point (by six older and six younger speakers of Standard Swedish) is included in the upper left corner of each map.

Because of the problem of speaker-dependent variation in acoustic measures of vowel quality (§ 2.4.3), variation in vowel pronunciation across individual speakers is difficult to study. In this thesis a normalization of the variation related to speaker-sex is applied (§ 5.1.5) and averages of a number of speakers are used in order to reduce the individual variation related to anatomical/physiological differences. As long as all older speakers and all younger speakers at a site pronounce all vowels similarly,
Figure 6.1. The 19 vowels in the PC2/PC1 plane. The one standard deviation ellipses are drawn based on the average PC values of the two speaker groups (older and younger speakers) at each site measured at the temporal midpoint of each vowel.
using group averages gives a good representation of the vowel pronunciation. A risk with using averages is, however, that variation within speaker groups might be lost. For example, if there would be a case where half of the speakers in a group pronounce a vowel more close and the other half of the speakers more open, the group average would indicate a pronunciation between these two, which would actually be true for none of the individual speakers. Therefore, some caution has to be taken when interpreting group averages. In a study as large-scaled as the present one, with nearly a hundred sites and more than one thousand speakers, the group averages should still give a good indication of the geographic and generational variation.

In this section the variation in each vowel is described and the maps are interpreted. The maps give an overall impression of the dialectal variation. Because some fine-grained differences between sites are hard to detect in the color spectrum in the maps, the numeric values in the original data files were examined, too, for a thorough description of the variation. When unexpected results or outliers were found in the data, a comparison was made with the sound files in order to exclude the possibility that mistakes in the segmentation or in the acoustic analysis of the vowels would influence the analyses.

In the appendix the maps are organized such that the corresponding long and short vowels are placed adjacent with the long vowel first when both vowels are present in the data set. Front vowels are presented first, starting with the close unrounded front vowels and going on with more open and rounded front vowels. After the front vowels the back vowels are presented in the reversed order, that is, starting with the most open back vowels and ending with the close ones. Below, the vowels are presented in the same order as in the appendix, which is: *dis* (Standard Swedish /iː/), *disk* (/ɪ/), *typ* (/yː/), *flytta* (/y/), *leta* (/ɛː/), *lett* (/ɛ/), *lus* (/uː/), *nät* (/eː/), *lär* (the pre-/r/ allophone [æ:] of /ɛː/), *särk* (the pre-/r/ allophone [æ] of /ɛ/), *söt* (/ɔː/), *lös* (/ɔːː/), *dör* (the pre-/r/ allophone [ɔː] of /ɔːː/), *dörr* (the pre-/r/ allophone [ɔː] of /œː/), *lat* (/aː/), *lass* (/aː/), *lös/låt* (/ɔːː/), *lott* (/ɔː/), *sot* (/uː/).

### 6.1.1 *dis* /iː/

The PC values of the vowel elicited with the word *dis* are displayed in Figure C.1 (p. 214). The Standard Swedish pronunciation of the vowels is [iː]. As can be seen in Figure 6.1, the vowel has low PC1 values and high PC2 values, which yields the blue colors in the maps in Figure C.1. The orientation of the ellipse of the vowel in Figure 6.1 shows the main direction of variation. The PC2 values vary more than the PC1 values across sites and generations, but the two variables co-vary to some extent.

In the South Swedish area, the maps displaying vowel quality close to onset show somewhat lighter blue colors than the maps of vowel quality close to offset. This holds for both the older and the younger speakers. The lighter color indicates higher

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2That is, phonologically corresponding long and short vowels, written with the same orthographic symbol. See Table 2.1 (p. 17).
6.1. Variation per vowel

PC1 values, that is, a more open vowel. Close to offset most of these dialects have clear blue colors. This fits well with the South Swedish diphthongization described in § 2.3.2.1. The long vowel is pronounced as a closing diphthong, which begins with a more open pronunciation and ends approximately with the Standard Swedish vowel quality.

Younger speakers at many sites in Götaland have lighter blue colors at both measuring points, which suggests a more open pronunciation throughout the vowel than in other varieties. A more open pronunciation than the Standard Swedish one was also shown to be the most frequent pronunciation of /iː/ by teenagers in the surroundings of Alingsås in Västergötland (to the north-east of Göteborg) by Grönberg (2004). Relatively high PC1 values are also found for younger speakers in the province Närke (Stora Mellösa, Viby) and in the neighboring location Järnboås (Västmanland).

An area comprising many Svealand varieties and the Finnish south coast has markedly low PC2 values (darker color). Because of the lower correlation between PC2 and F2 than between PC1 and F1, especially for high F2 values (see Figure 5.13, p. 77), it is not possible to tell if the lower PC2 values in this area are due to a low F2 or some other spectral feature that these varieties share. Low F2 values could be an indication of the so-called “damped” i (§ 2.3.2.5), which is reported in many scattered dialects, for example in Uppland, south Bohuslän, south Östergötland and Medelpad (Elert, 2000, 44–45). However, the damped pronunciation has not previously been attested in Finland-Swedish varieties and is therefore not likely to be found there.

6.1.2 disk /ɪ/

Figure C.2 (p. 215) shows the PC values of the vowel in the word disk. The Standard Swedish pronunciation of the vowel is [ɪ]. Both the average PC1 and the average PC2 values of the vowel in disk are somewhat higher than in the corresponding long vowel (the vowel in dis), as can be seen in Figure 6.1 (p. 87). The vowel shows relatively little variation across sites and generations. The PC2 values vary more than the PC1 values.

Older speakers in the province Dalsland and on the Swedish west coast have higher PC1 values than what is found elsewhere. Younger speakers have somewhat higher PC1 values than older speakers in general.

As was the case for the vowel in dis, the Svealand dialects and dialects along the Finnish south coast have lower PC2 values in disk than what is found in the rest of the language area. This holds especially for the older speakers.

The differences between vowel quality close to onset and close to offset are very small. Only an area in the west of Götaland shows a larger difference, especially for the older speakers. It is mainly the PC1 value that is higher close to offset than close to onset.
6.1.3 typ /y:/

The maps displaying the vowel in typ are found in Figure C.3 (p. 216). In Standard Swedish the vowel is a close rounded front vowel, [y:]. The average PC values are higher for the vowel in typ than for the Standard Swedish unrounded close front vowel in dis (see Figure 6.1, p. 87), but the main direction of variance is roughly the same.

In the South Swedish area, a clear difference between the values close to onset and close to offset can be seen in the maps. The PC1 values are high close to onset and lower close to offset. The same thing was noted for the vowel in dis (§ 6.1.1). These closing diphthongs are part of the South Swedish diphthongization (see § 2.3.2.1). Also Näpes in Finland shows a similar kind of diphthongization in typ.

As for the vowel in dis, younger speakers at many sites in Götaland and in Stora Mellösa (Närke), Viby (Närke) and Järnboäs (Västmanland) have light blue colors at both measuring points, which suggests a relatively open pronunciation throughout the vowel in typ.

The lowest PC2 values are found in Svealand and on the Finnish south coast, as well as in Bohuslän.

6.1.4 flytta /y/

The PC values of the vowel elicited with the word flytta (y) are displayed in Figure C.4 (p. 217). The Standard Swedish pronunciation is [y]. The PC1 values are higher than for the long y in typ resulting in lighter colors in the maps. The average PC2 values are lower than for the typ vowel. Both the PC1 and PC2 values of the flytta vowel vary a great deal and independently of each other giving the almost round ellipse in Figure 6.1 (p. 87). The maps showing pronunciation close to onset and close to offset are relatively similar.

Of the short front close vowels, the flytta vowel shows considerably more variation than the disk vowel. A western area, from the province of Bohuslän in the south to Jämtland in the north, including some sites on the east coast of Norrland, has high PC1 values, resulting in lighter blue colors and suggesting a more open pronunciation than in Standard Swedish. For younger speakers in Götaland the PC1 values are not as high as for the older speakers. In the more northern provinces, however, the lighter colors are found in both generations. This opening of the vowel in flytta could be the result of a change from Proto-Nordic short i and y to e and ö, which is considered a typical feature for Götaland dialects (Pettersson, 2005, 151, 224). Pamp (1978, 88) notes that this southern feature has also spread to parts of the province Värmland. In Härjedalen, Pamp (1978, 120) mentions a change from y to ö in front of some consonants or consonant combinations (namely nd, ns, nt, m, v and f), but he does not mention a change in front of t. For the province Jämtland, Pamp (1978) does not mention a lowering of y.

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3Dialects in Svealand and further to the north were also affected by this change, but in a more restricted number of phonological contexts.
When it comes to the PC2 values, lower values than in other varieties are found in a similar area as for the other close front vowels, that is, mainly in Svealand and on the Finnish south coast. Very low values are also found in Skee (Bohuslän). The highest PC2 values are found in Norrland.

6.1.5 leta /e:/

The root vowel, \(\text{e}^{\text{a}}\), in the word leta is displayed in Figure C.5 (p. 218). The Standard Swedish pronunciation is \([\text{e}]:\). The vowel shows considerable variation across varieties, especially on the PC1 values (see Figure 6.1, p. 87). The maps displaying the PC values near onset and near offset are quite different. There is a general trend towards lighter colors close to offset than close to onset, which means higher PC1 values and a more open pronunciation close to offset. But other types of diphthongization can be identified as well.

PC1 values that increase towards offset are especially prominent among younger speakers. A similar opening of \(/\text{e}:/\) towards the end of the vowel was also found in formant measurements of speakers from the greater Stockholm area by Eklund & Traummüller (1997) (see § 2.3.1).

An opposite kind of diphthongization, high PC1 values close to onset that decrease towards offset, is found among South Swedish varieties (mainly in Skåne), on Gotland, in Jämtland (Aspås, Berg, Åre) and Norrbotten in Norrland, and in Houtskär (Åboland) and Närpes (Österbotten) in Finland. The highest PC1 values close to onset are found in Närpes. Older speakers in Överkalix (Norrbotten) have a large difference between onset and offset in the PC2 values, too. The vowel in leta was a diphthong, \(/\text{ai}/\), in Proto-Nordic. The Proto-Nordic diphthongs were monophthongized in most varieties of Swedish, but were preserved in dialects on Gotland, parts of Norrland and in Finland (except Åland) (Pettersson, 2005, 211). In the present data set the diphthongization values are lower for younger speakers than for older speakers in all sites where the Proto-Nordic diphthong has been preserved. It seems that the diphthong is disappearing in Norrland. Younger speakers on Gotland have higher diphthongization values than the younger speakers in Norrland, but the difference between values near onset and near offset is still so small for the younger speakers on Gotland that it is hardly recognizable in the color spectrum in the maps. This could mean that only a few of the younger speakers on Gotland are using the variant with the diphthong. In Finland the diphthong is only found at two sites in the data set. At these two sites it seems to be stable, that is, present also among younger speakers.

In South Swedish, Proto-Nordic diphthongs have not been preserved, but the diphthongization of \(/\text{e}/\) is part of the South Swedish diphthongization (§ 2.3.2.1), which affects all long vowels.

For PC2, a very similar pattern as for other front vowels, discussed above, is found.
6.1.6 lett /ɛ:/

In Figure C.6 (p. 219), the maps display the PC values of the vowel in lett. In Standard Swedish the vowel is pronounced [ɛ], that is somewhat more open than the corresponding long vowel [e:]. Also in many of the dialects the vowel in lett is more open than the vowel in leta, as can be seen by the lighter colors in the maps. Figure 6.1 (p. 87) shows that the PC1 values vary more than the PC2 values, exactly as for the corresponding long vowel. For the short vowel the differences between values close to onset and close to offset are not as large as for the long vowel. The PC1 values show more diphthongization than the PC2 values.

The maps of the younger speakers have more light colors than the maps of the older speakers. This is due to higher PC1 values, which suggests a more open pronunciation among younger speakers. At almost all sites (but eight), the younger speakers have higher PC1 values than the older speakers.

The older speakers in Sproge (Gotland) and Överkalix (Norrbotten) have very high PC1 values and low PC2 values close to onset. The PC1 values decrease and PC2 values increase towards offset. Like in leta (§ 6.1.5) the vowel in lett was the diphthong /ai/ in Proto-Nordic. The PC values of Sproge and Överkalix suggest that the Proto-Nordic diphthong has been preserved in these varieties. A similar diphthongization on PC1, but to lesser extent, is found for example in Frostviken and Strömsund in Jämtland, Södra Finnskoga (Värmland), Piteå (Norrbotten) and Ankarsrum (Småland). For the short vowel in lett fewer dialects have preserved the diphthong than for the long vowel in leta.

Diphthongization along PC1 into the opposite direction is found in Västergötland. Here, the PC1 values are relatively low close to onset, but increase remarkably resulting in a very light color close to offset.

The PC2 values show a similar pattern as for other front vowels, that is, low values are found at many sites in Svealand and along the Finnish south coast.

6.1.7 lus /uː/

The vowel in lus is displayed in Figure C.7 (p. 220). The linguistic variation is considerable, especially along PC2, as can be seen also in Figure 6.1 (p. 87).

In east Svealand and at some sites in western parts of Norrland, younger speakers have higher PC1 values than older speakers, suggesting that the pronunciation of the vowel is becoming more open. A development of /uː/ to a more open, more fronted and less rounded vowel in the town Eskilstuna in Södermanland (about 100 km west from Stockholm) has been described by Nordberg (1975). This development co-varies to some extent with the opening of /ɔː/ in Eskilstuna (see § 6.1.11). The higher PC1 values among younger speakers as compared to older speakers in the present data set could indicate a similar development.

At many sites in Götaland and Norrland, the more open pronunciation is found among both older and younger speakers. An open pronunciation of /uː/ among teenagers in Västergötland has been described previously by Grönberg (2004).
Some of the sites along the Finnish south coast have a dark yellowish color very
different from the color of most sites in Sweden. These dialects have very low PC2
values. As mentioned in § 2.3.2.7, the pronunciation of the *lus* vowel was [u:] in
Proto-Nordic, but the pronunciation has been fronted during the centuries. In many
dialects in Finland the fronting has not proceeded as far as in most parts of Sweden.
Markedly low F2 values in /u:/ in Finland-Swedish as compared to the standard
language in Sweden have been measured by Reuter (1971) and Kuronen (2000).
Apart from in Finland, low PC2 values are also found in Skeo and among older
speakers in Malung. In Skeo the PC1 values are lower resulting in a darker color.

Diphthongized pronunciations of the *lus* vowel are found in South Swedish vari-
elies, on Gotland and in a few other scattered sites. In the South Swedish area,
the PC1 values decrease during the vowel (going from gray to blue on the maps),
indicating a closing vowel. On Gotland, on the contrary, the PC1 values increase
during the vowel segment, and the change in PC2 values is larger than for PC1.
The PC2 values decrease during the vowel on Gotland. Elert (2000, 42) mentions
the pronunciation [u] for /u:/ in standard-like speech on Gotland and Pamp (1978,
77) describes the pronunciation of /u:/ in Gotlandic dialects as eo (IPA: [eu]) or åo
(IPA: [eu]). The low PC1 values in the varieties on Gotland in Figure C.7 suggest a
relatively close pronunciation close to onset.

In Norrbotten, diphthongization is found among older speakers, but the four sites
in Norrbotten have different types of diphthongization. A similar diphthongization
to that on Gotland is found for older speakers in Nederluleå. In Överkalix the PC1
values close to onset are higher than in Nederluleå and the change in PC2 is smaller.
In Kalix the PC1 values close to onset are very high and decrease towards offset,
while the change in PC2 is small.

In Vörå (Österbotten), there is a relatively large change in PC2 between onset
and offset (higher close to onset than close to offset) and the PC1 values are relatively
high. Older speakers in Dragsfjärd (Åboland) have higher PC2 values close to onset
than close to offset, too.

### 6.1.8 nät /ɛ:/

The vowel in nät has the highest average PC2 value of the vowels in the data set (see
Figure 6.1, p. 87). The PC1 values vary more across dialects than the PC2 values.
The vowel is relatively open (Standard Swedish [ɛ:]) resulting in light colors in the
maps in Figure C.8 (p. 221).

In the map of vowel quality close to onset of the older speakers, an eastern area
can be distinguished from the rest. This area includes Uppland, Gotland and many
Finland-Swedish varieties except for the ones spoken on the Åland islands. The sites
in this area have a darker color than most other sites, which means lower PC1 values
and suggests a closer pronunciation. The dialects close to Stockholm, in Uppland
and Södermanland, and some dialects in Finland are known from the literature (see
§ 2.3.2.6) to lack the distinction between /ɛ:/ and /ɛː/, and both phonemes are
pronounced [ɛ:]. On Gotland the pronunciation of /ɛː/ is close to [ɛ:], too, but the
phonemic distinction is maintained because /e:/ is diphthongized, [ei] (Elert, 2000, 47).

Outside the area mentioned, low PC1 values are found also in Malung in Dalarna and in Skee and Orust in Bohuslän.

On Gotland and in Närpes (Österbotten), the PC1 values are much lower close to onset than close to offset, indicating an opening diphthong in these dialects. This is in line with the Gotlandic diphthongization of mid vowels (see § 2.3.2.3). From Närpes the pronunciation [me:t] is reported in Ordbok över Finlands svenska folkmål (Ahlbäck & Slotte, 1976–2007).

In the South Swedish area, there is also diphthongization, especially among the older speakers. This diphthongization goes in the opposite direction than the one on Gotland: the PC1 values are higher close to onset than close to offset. This matches the description of South Swedish diphthongization (§ 2.3.2.1): long front vowels are pronounced as closing diphthongs that start with a more open pronunciation and end approximately with the Standard Swedish vowel quality.

The maps of the younger speakers generally have lighter colors than the maps of the older speakers. Only at seven sites (Borgå, Burseryd, Fole, Jämshög, Malung, Snappertuna, Össjö) do younger speakers not have higher PC1 values close to onset than the older speakers. The dialects in the surroundings of Stockholm are the ones that seem to be changing the most. Elert (2000, 47) notes that the close [e:] in words like nät for a long times has been regarded as not generally accepted Stockholm pronunciation and that this pronunciation is decreasing in use. As reasons for the change, Elert mentions the general trend towards a more orthographic pronunciation and that the merger of /e:/ and /e:/ has not been accepted by school teachers.

The diffusion of an even more open pronunciation of /e:/ (in other contexts than before /r/) has been noted among teenagers in Eskilstuna (Hammermo, 1989) and Stockholm (Kotsinas, 1994). In both studies, the extremely open pronunciation [æ:] was used more by girls than by boys.

Young speakers on Gotland, in Finland and in Malung (Dalarna) seem to hold on to a close pronunciation of the nät vowel. From being an eastern dialect feature, the close pronunciation of the nät vowel has, hence, changed to a peripheral feature.

6.1.9 lär [æ:]  
The vowel in the word lär is displayed in the maps in Figure C.9 (p. 222). In Standard Swedish the vowel is an open front vowel, [æ:] (the pre-/r/ allophone of /e:/). In the dialects both the PC1 and PC2 values are high, resulting in light colors in the maps. The PC1 values vary more than the PC2 values, as can be seen in Figure 6.1 (p. 87), but the oblique direction of the ellipse shows that the PCs vary to some extent dependently of each other: higher PC1 values mean lower PC2 values.
The maps show that there is a large difference between older and younger speakers. The maps of the younger speakers are lighter, indicating higher PC1 values which means a more open pronunciation.

In the maps of the older speakers an eastern area can be distinguished. This area includes Uppland, Gotland and Finland. In this area light yellow or grayish shades (high PC1) are found, while the rest of the language area is blue. The high PC1 values correspond to the open Standard Swedish pronunciation of the vowel \[æ\:]. The lowest PC1 values are found at a few sites in Norrland (Aspås, Färila, Kalix, Nederluleå, Strömsund) in Houtskår (Åboland) and around the lake Vänern. In the area around Vänern the PC1 values increase towards offset, while the difference between onset and offset does not seem to be that large in most of the Swedish area. The PC2 values vary less among the older speakers than the PC1 values and they are more stable between onset and offset. The eastern area (especially Uppland and Finland) has somewhat lower PC2 values than the other dialects, as shown for other front vowels.

Elert (2000, 48–49) notes that almost all varieties of Standard Swedish have a more open pronunciation of /ɛ:/ when it is immediately followed by an \(r\) than in other positions, but the degree of openness of the more open allophone varies a lot. According to Elert, the most open pronunciations are found in the east, for example in Stockholm. More to the west, the vowel can be relatively close, even to the degree that the pronunciation of /ɛ:/ is the same in all positions. Comparing the maps of nät (Figure C.8) and lär (Figure C.9) of the older speakers, it is obvious that the largest difference between the two vowels is made in Uppland, Gotland and Finland. For many sites in Götaland and Norrland the color is very similar for the two vowels, suggesting only a small or no difference.

Nordberg (1975) mentions that there is a social stratification of the pronunciation of /ɛ:/ in the town Eskilstuna in Södermanland. In Nordberg’s study, the highest social group followed the Standard Swedish norm by using [æː] before /r/ and [ɛː] in other contexts. In the lower social group, however, younger speakers had generalized [æː] in all context, while older speakers used [ɛː] in all contexts.

What Elert (2000) describes holds for the lär vowel of older speakers in the present data set. In the east the pronunciation is more open than in the west. But in the younger generation a very different picture emerges. The yellow color that is found only in the east for the older speakers has spread markedly among younger speakers. At all sites except five (Fole, Fårö, Gräsö, Haraker and Närpes) in the data set the younger speakers have on average higher PC1 values close to onset than the older speakers. A similar trend was noted for the nät vowel in the previous section. The general opening of /ɛ:/ by younger speakers, which Nordberg (1975) found in the lower social group in Eskilstuna and which Hammerno (1989) and Kotsinas (1994) noted especially for young girls in Eskilstuna and Stockholm (see above § 6.1.8), seems to have spread to almost the whole language area.

\(^4\)In Uppland and Finland the pronunciation of /ɛ:/ is so close that the phonemes /ɛ:/ and /æː/ have merged. On Gotland the pronunciation of /ɛ:/ is very close, too, but because /ɛ:/ is diphthongized, there is no merger. See § 6.1.8.
In the eastern area, where the older speakers have an open pronunciation of the lär vowel, the difference between older and younger speakers is small. In Kalix and Nederhuleå in Norrbotten (where the older speakers have markedly low PC1 values) the difference between older and younger speakers is the largest.

6.1.10 särk [æ]

The vowel in the word särk is one of the least variable according to the ellipses in Figure 6.1 (p. 87). The vowel is an open front vowel in Standard Swedish, [æ], and the high PC1 and PC2 values suggest that the same is true for most dialects. Accordingly, the maps in Figure C.10 (p. 223) show only light blue and light yellow colors.

The PC1 values are somewhat higher in Norrland than in Svealand and Götaland. This is more true for the older speakers than for the younger speakers. As for other front vowels, the lowest PC2 values are found in many places in Svealand.

An area including sites in the provinces Närke, Södermanland and Västmanland has lower PC1 values and higher PC2 values than most other areas, resulting in a more blue color. Relatively low PC1 values close to onset are also found for the older speakers in Överkalix (Norrbotten) and for older speakers in the South Swedish area.

Differences between onset and offset are generally not large in särk. In the South Swedish area, however, the PC1 values increase towards offset.

6.1.11 söt /ø:/

The pronunciation of the vowel in the word söt (Standard Swedish [ø:]) is relatively homogeneous among older speakers. The blue color throughout the map of the pronunciation of older speakers in Figure C.11 (p. 224) indicates high PC2 values.

There is a general tendency towards a more open pronunciation (higher PC1 values) close to offset, compared to that of onset, manifested in lighter colors in the maps displaying the pronunciation close to offset. This is in line with the diphthongization of mid vowels in Stockholm speech reported by Eklund & Traunmüller (1997) (see § 2.3.1). Dialects in the provinces Skåne, Gotland and Norrbotten go against this general trend having a more close manner of articulation at offset than at onset, indicating a closing diphthong.

The maps show a large difference between older and younger speakers in some areas. Younger speakers have higher PC1 values than older speakers in general, which indicates that the pronunciation is becoming more open. Nordberg (1975) describes the development of a more open pronunciation of /ø:/ in Eskilstuna in Södermanland. Eskilstuna was industrialized in the 19th century, with rapid growth and immigration from the surrounding countryside as consequences. In the surrounding rural dialects there was no open allophone of /ø:/, but the vowel was a mid-close vowel in all contexts. When the immigrants in Eskilstuna wanted to imitate the more prestigious Stockholm pronunciation, they started to use the open allophone [œ:] of /ø:/, which is used only before /r/ in Standard Swedish. However,
they overgeneralized the open allophone and used it in positions other than before /r/ as well. This “socio-linguistic hypercorrection" (Nordberg, 1975, 603) became a well known feature in the local vernacular of Eskilstuna, but the pronunciation was heavily stigmatized and it was not accepted in schools. In Nordberg’s data from the end of the 1960s, speakers in the lower social group had a more open pronunciation than the higher social group. However, there was also a correlation with age: the younger the speaker, the more open the pronunciation. Men used more open variants than women, and the youngest men (age 16–30) in the higher social group had an as open pronunciation as the young speakers in the lower social group. The open pronunciation was, hence, spreading from the lower social group to the higher social group, which suggested a change from below was in progress. In a study of school children recorded in Eskilstuna in 1977–79 Hammermo (1989) found similar social stratifications and age-related variation in the /ø:/ vowel as Nordberg (1975), but in Hammermo’s data the young girls were using more open variants than the boys.

Nordberg (1975) mentions that apart from in Eskilstuna, a more open pronunciation of /ø:/ was spreading quickly among younger speakers in central Sweden. In Stockholm, this open pronunciation was considered rural and was stigmatized. However, in a study of the language of teenagers in Stockholm recorded in 1989–1991, Kotsinas (1994) showed that the open pronunciation of /ø:/ had become regular among both lower-class and upper-class teenagers. Andersson (1994) noted that an open pronunciation of /ø:/ was becoming common among young speakers in Göteborg, too, and Grönberg (2004) characterized the open variant of /ø:/ as marker of Swedish youth language, particularly associated with the language of young people in the cities.

In the maps in Figure C.11 the most open pronunciations among older speakers are found in Medelpad, Härjedalen, Åland, Gräsö (Uppland) and northern parts of Östergötland. The shift towards a more open pronunciation seems to be strongest in central Sweden and along the coast in the west. In this area, younger speakers have significantly higher PC1 values and to some extent also lower PC2 values than older speakers. Also for the speakers who represent Standard Swedish a clear difference between older and younger speakers can be noted. Norrland and mainland Finland are less affected by this opening of the söt vowel and so are the provinces Västergötland and Dalsland.

From previously having been a socio-linguistic hypercorrection and a stigmatized variant, the open pronunciation of /ø:/ has spread to a large geographic area distinguishing younger speakers from older speakers.

6.1.12 lös /ø:/

Even though the vowels in the words lös and söt are the same vowel phoneme in Standard Swedish, /ø:/, the vowel in lös varies more across dialects than the vowel in söt, as can be seen by the size of the ellipses in Figure 6.1 (p. 87). The maps displaying the vowels in söt (Figure C.11, p. 224) and lös (Figure C.12, p. 225) look
relatively similar for the younger speakers, but differ in some areas for the older speakers.

In Proto-Nordic lôs had a diphthong, while sôt had a monophthong (see § 4.2.1). Some dialects have preserved the vowels as two different phonemes. In the maps, differences between the two vowels are found mainly among older speakers in Norrland. Above all the difference in the provinces Jämtland and Härjedalen is striking. The diphthongization of the vowel in lôs is strongest among older speakers in Kalix and Nederluleå in Norrbottn and Burträsk in Västerbotten. In Kalix and Nederluleå the PC2 values decrease towards onset, while the PC1 values increase. In Burträsk the PC1 values decrease considerably towards offset.

6.1.13 dör [œː]

The vowel in dör has the largest ellipse in Figure 6.1 (p. 87), and is, hence, the most variable vowel. Both the PC1 and the PC2 values show considerable variation and there is a correlation between the two variables: higher PC1 values generally go with lower PC2 values. The maps in Figure C.13 (p. 226) show both large geographic variation and variation across the two age groups of speakers. The Standard Swedish pronunciation is [œː]. The clear blue color in many areas in the maps suggests a much more close pronunciation than in Standard Swedish. The difference between values close to onset and close to offset are also large for some dialects.

The PC1 values are generally lower close to onset than they are close to offset and for most varieties the PC2 values decrease towards offset. Among older speakers, high PC1 values are found mainly in an eastern area. This includes almost the whole east coast of Sweden, with the islands Gotland and Öland and many of the sites in Finland. The South Swedish varieties have high PC1 values as well.

Relatively low PC1 values and high PC2 values close to onset are found among older speakers in most of Götaland and in provinces close to the Norwegian border (Värmland, Härjedalen). A close pronunciation of /øː/, also before /r/, was considered typical for the dialects of Västergötland—the core area of Götaland—by Landtmanson (1952, 38–39).

There is a large difference between older and younger speakers in the dör vowel. The younger speakers have higher PC1 values than the older in all but eight of the sites in the data set. Only in a small western area are low PC1 values found among the younger speakers. This area includes the provinces Västergötland and Dalsland. Grönberg (2004) studied the variable ‘/øː/ before /r/’ among teenagers in Västergötland and found a surprisingly high frequency of the local close variant of the vowel. While some other features of the traditional local dialect were disappearing rapidly, the close pronunciation of /øː/ before /r/ seemed persistent, which led Grönberg to conclude that “there is a chance that it would live on as a part of a West Swedish or Västgöta regional standard” (Grönberg, 2004, 344). This statement seems to be supported by the results in the maps in Figure C.13 (even though the subjects of Grönberg’s study were recorded at about the same period in time as the subjects of this thesis which means that no diachronic conclusions can be made).
Many of the Norrland varieties (particularly older speakers) have very high PC2 values. Dialects in Uppland, Gotland and along the Finnish south coast have low PC2 values. Among younger speakers, the lowest PC2 values are found on Gotland. In Uppland and on the Finnish south coast younger speakers have somewhat higher PC2 values than older speakers.

In Österbottien and Houtskär (Åboland) in Finland and among older speakers in Norrbotten and Jämtland the PC1 values are higher close to onset than close to offset. The decreasing PC1 values suggest that the Proto-Nordic diphthong, /eu/, has been preserved. In Norrbotten, in Närpes (Österbotten) and Sproge (Gotland) the PC2 values are also considerably lower close to onset than close to offset.

South Swedish varieties have higher PC2 values near onset than near offset of the vowel.

6.1.14 dörr [œ]

The vowel in dörr is displayed in Figure C.14 (p. 227). In Standard Swedish the vowel in this word is the open allophone [œ] of the phoneme /ø/. This vowel is known for its variability across dialects. In several places, especially in cities there is a merger of /œ/ and /ə/. The merger is more common before /r/ than in other contexts (Elert, 2000, 48).

The maps in Figure C.14 show clear geographic variation for the dörr vowel, but the variation is relatively stable across the two generations of speakers. The vowel in dörr varies less than the vowel in dör, as shown in Figure 6.11 (p. 87). Still, the geographic variation in the two vowels shows some similarities. Large differences between the two vowels are found particularly in Götaland and western parts of Svealand, where many dialects have higher PC1 values and lower PC2 values in the dörr vowel than in the dör vowel, which means dörr has a more open pronunciation than dör. In Uppland the PC1 values are lower for the dörr vowel than for the dör vowel.

Because /ə/ is not included in the data set (see § 4.2.2), it is not possible to make conclusions about a possible merger of the two vowels. However, gray colors on the maps, for example in Uppland, indicate a central vowel. A central pronunciation of /œ/ is likely to be rather similar to the pronunciation of /ə/.

The differences between values close to onset and close to offset are smaller for the dörr vowel than for the dör vowel. Large differences are found in Härjedalen and Jämtland and in Närpes in Finland, where the PC1 values are very low close to onset and increase towards offset. In the South Swedish area the PC1 values increase and PC2 values decrease towards offset.

The vowel in dörr is not unambiguously a short vowel in dialects even though it is a short vowel in Standard Swedish. In some dialects the vowel has been lengthened. Transcriptions of the present data set show that this is the case at least for dialects in Jämtland and Härjedalen and for some dialects in Dalarna.
6.1.15 lat /ɑː /

The vowel in *lat* is an open back vowel in Standard Swedish. The position of the ellipse of the vowel in the PC2/PC1 plane in Figure 6.1 (p. 87) and the yellow color in the maps in Figure C.15 (p. 228) suggest a similar pronunciation for most dialects. The dialectal differences are relatively small. When it comes to the PC1 values, there is only one outlier: the older speakers in Överkalix (Norrbotten) have an extremely low value compared to all other varieties.

High PC2 values are found among older speakers in Norrbotten and Västerbotten. Also in the South Swedish area very high PC2 values are found, Växtorp and Össjö having the most extreme values. On Gotland and in Finland the PC2 values are relatively high compared to most other varieties, too.

In a cluster analysis of Swedish dialects based on Mel frequency cepstral coefficients of the vowel in *lat*, Lundberg (2005) identified three dialect clusters.\(^5\) The first cluster, representing a “broad [ɑː] sound” according to Lundberg (2005, 43), included sites in northern Sweden, Finland, Skåne and Gotland. This cluster agrees well with the sites with high PC2 values in the *lat* vowel in the present analysis.

According to Lundberg (2005, 43), the two other clusters identified distinguished a more rounded pronunciation from the Standard Swedish one. This division could not be identified in the present analysis.

The vowel in *lat* was a short vowel in Proto-Nordic and was lengthened during the Swedish quantity shift. Of the sites included in the present study, at least Vörå (Österbotten) has preserved a short vowel phoneme in *lat*.

6.1.16 lass /a/

Figure C.16 (p. 229) displays the maps of the *lass* vowel. The total amount of variation is very small, which can also be seen in Figure 6.1 (p. 87). The PC2 values vary more than the PC1 values. The *a* in *lass* (Standard Swedish [a]) has higher PC1 and PC2 values than the *a* in *lat* (Standard Swedish [ɑː]).

In the South Swedish area, the PC1 values are lower than the average, while the PC2 values are relatively high, resulting in grayish colors. Bruce (2010, 139) mentions that the short *a* has a fronted pronunciation in southern Skåne, close to [æ], which fits with the PC scores. Similar scores as for the South Swedish varieties are also found for some sites in Norrland (for example, Delsbo, Nederluleå, Överkalix), especially for the older speakers.

6.1.17 lås/låt /ɔː/

The vowel elicited with the words *lås* and *låt*, displayed in Figure C.17 (p. 230), is a close-mid back vowel in Standard Swedish, [ɔː]. Also in most dialects the vowel is a back vowel, with colors between black and yellow in the maps (the extremely dark color of the Standard Swedish reference point is a result of the higher signal-to-noise ratios in the recordings of the standard speakers, compare § 5.1.6).

\(^5\)The data of the study comprised older male speakers from the SweDia database.
The most striking in the maps is the bluish color close to vowel onset for South Swedish varieties. These varieties have extremely high PC2 values close to onset. The high PC2 values are most extreme in the province of Skåne. Close to the offset these dialects have much lower PC2 values, which indicates a diphthongized pronunciation. The PC1 values found here are also high compared to other dialects, which suggests a relatively open pronunciation. The PC1 values do not differ much between onset and offset. The South Swedish pronunciation of Standard Swedish /o:/ is, according to Elert (2000, 38), [ˈoː]. The PC values fit this pronunciation well.

Other varieties with a diphthongized pronunciation are found on Gotland, where both the PC1 and the PC2 values are higher close to offset than close to onset. Elert (2000, 42) gives the pronunciation [oːt] for Standard Swedish /o:/ on Gotland, which agrees with the PC values.

The lowest PC1 values and the lowest PC2 values close to onset for the lås/låt vowel are found in Svealand. Both PC values are somewhat higher close to offset than close onset.

In Finland, the PC2 values are generally also low, but the PC1 values are higher than in Svealand.

In Norrbotten and a few other places in Norrland (for example Ärjeplog, Berg), high PC1 values are found close to onset especially among the older speakers. Close to offset the PC1 values are lower.

6.1.18 lott /ɔ/  

The vowel in lott (Standard Swedish [ɔ]) shows very little variation across sites and generations on PC1 and considerably more variation on PC2 (see Figure 6.1, p. 87). The maps are displayed in Figure C.18 (p. 231). The PC1 and PC2 values are higher than in the corresponding long vowel (the vowel in lås and låt).

Particularly high PC2 values are found for dialects in Härjedalen and Dalarna (bluish color on the maps). Low PC2 values are found among Finland-Swedish varieties, in Uppland and a few other scattered varieties. Many varieties in Götaland have higher PC2 values close to onset than close to offset. The opposite holds for many of the sites in Norrland, in southern Finland and on Gotland.

6.1.19 sot /uː/  

The vowel in the word sot is a close back vowel in Standard Swedish, [uː], and has dark colors for most varieties in the maps in Figure C.19 (p. 232). As for the other long back vowel (the vowel in lås and låt, § 6.1.17) the South Swedish area is distinguished from other dialects by having a diphthongized pronunciation with a blue color close to onset. For the sot vowel the blue southern area reaches further to the north than for the lås/låt vowel.

Other areas, where strong diphthongization is found for the sot vowel, are Gotland, Norrbotten (older speakers), Österbotten and to somewhat lesser degree in Östergötland and neighboring sites in Småland. In these areas both PC values are
relatively high close to the onset, but decrease towards the offset of the vowel, indicating a closing diphthong.

In many places in Norrland the PC2 values are somewhat higher close to offset than close to onset resulting in a bluish color.

6.2 Vowel comparison

The maps discussed in § 6.1 show that some of the vowels analyzed are relatively stable geographically and across generations. Other vowels show large variation between sites or seem to be changing. This section summarizes the data of the 19 different vowels and compares the amount of geographic dispersion (§ 6.2.1) and the amount of change (§ 6.2.2) across the vowels.

For measuring the amount of geographic variation the acoustic distances between all pairs of sites were calculated for each vowel. In order to measure the amount of change per vowel the acoustic distances between older and younger speakers at each site were calculated. These distances were measured as the Euclidean distance of the two PCs measured at nine different points within each vowel segment starting at 25% of the total vowel duration and ending at 75%.

Equation 6.1 shows the Euclidean distance, where $i$ ranges over the nine sampling points per vowel and $x$ and $y$ are either two different sites (§ 6.2.1) or older and younger speakers at one site (§ 6.2.2):

$$distance(x, y) = \sqrt{\sum_{i=1}^{9} ((PC1_{xi} - PC1_{yi})^2 + (PC2_{xi} - PC2_{yi})^2)} \quad (6.1)$$

6.2.1 Geographic variation

For measuring the degree of geographic variability, the pair-wise Euclidean distances (Equation 6.1) between all sites in the data set were calculated for each vowel. This was done separately for the older and the younger speakers. The average values of the vowel pronunciation of each speaker group at each site were used when calculating the Euclidean distances. Only sites where all vowels were recorded were included to make sure that the comparison of the vowels would not be biased by missing data. In the older speaker group all vowels were recorded at 89 sites, while the number of sites with all vowels in the younger speaker group was 91, which lead to 3,916 pair-wise distances between sites for older speakers and 4,095 distances for younger speakers.6

Table 6.1 displays the median of the pair-wise distances per vowel in each age group. The vowels are listed according to descending distance for each age group separately. The median was chosen instead of the mean as a measure of central tendency, because for some words there are extreme outliers in the data set. For example, the few dialects that have preserved old diphthongs in words like leta, lös

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6The number of pair-wise distances between items is $(n \times (n - 1))/2$. 
6.2. Vowel comparison

Table 6.1. Median acoustic distances between sites per vowel, for older and younger speakers. The vowels are listed in order of descending distance for each age group separately.

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Median</th>
<th>Vowel</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>dör</td>
<td>2.23</td>
<td>dör</td>
<td>1.88</td>
</tr>
<tr>
<td>sot</td>
<td>2.01</td>
<td>sot</td>
<td>1.73</td>
</tr>
<tr>
<td>lus</td>
<td>1.82</td>
<td>lös</td>
<td>1.72</td>
</tr>
<tr>
<td>flytta</td>
<td>1.78</td>
<td>söt</td>
<td>1.67</td>
</tr>
<tr>
<td>lös</td>
<td>1.73</td>
<td>dis</td>
<td>1.57</td>
</tr>
<tr>
<td>lär</td>
<td>1.70</td>
<td>flytta</td>
<td>1.56</td>
</tr>
<tr>
<td>leta</td>
<td>1.69</td>
<td>lus</td>
<td>1.52</td>
</tr>
<tr>
<td>lås/låt</td>
<td>1.69</td>
<td>typ</td>
<td>1.46</td>
</tr>
<tr>
<td>nät</td>
<td>1.61</td>
<td>nät</td>
<td>1.45</td>
</tr>
<tr>
<td>dörr</td>
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<td>lås/låt</td>
<td>1.42</td>
</tr>
<tr>
<td>lat</td>
<td>1.56</td>
<td>leta</td>
<td>1.41</td>
</tr>
<tr>
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<td>lett</td>
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<td>dörr</td>
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<td>lott</td>
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<td>1.26</td>
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<tr>
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<td>1.21</td>
<td>lass</td>
<td>1.01</td>
</tr>
<tr>
<td>särk</td>
<td>1.19</td>
<td>särk</td>
<td>0.99</td>
</tr>
<tr>
<td>mean</td>
<td>1.61</td>
<td>mean</td>
<td>1.41</td>
</tr>
</tbody>
</table>

and dör have very large distances to the other sites on these vowels (see, for example, sites with yellow color close to onset in the maps of leta, Figure C.5, p. 218).

Almost all distances in Table 6.1 are larger for the older speakers than for the younger (but compare söt in both lists). The mean is 1.61 for the older speakers and 1.41 for the younger speakers. This difference is significant (Paired Samples t-test, \( t(18) = 5.06, p < 0.001 \)), which means that there is less geographic variation in the pronunciation of the vowels among younger speakers than among older speakers.

The two vowels found at the top of the table for both age groups, and, hence, the ones varying the most geographically in both generations of speakers, are the vowels in dör and sot. The median distance between sites for the vowel in dör is 2.23 for the older speakers and 1.88 for the younger speakers. The median distances of the sot vowel are 2.01 for older speakers and 1.73 for younger speakers. In both cases, the median distance between sites is shorter for younger speakers than older speakers. Even if the amount of variation in these vowels seems to be decreasing, they still remain the most variable of the vowels in the data set.

Also the three least variable vowels are the same for older and younger speakers: the vowels in disk, lass and särk. These vowels have median distances close to 1 for the younger speakers and between 1.19 and 1.30 for older speakers.
For both older and younger speakers long vowels vary more than short vowels. This is expected based on the previous knowledge of Swedish vowels described in § 2.3. Regional varieties of Standard Swedish vary more in their pronunciation of long vowels than of short vowels (see § 2.3.2) and in the rural dialects the long vowel systems are more variable than the short vowel systems (see § 2.3.3).

The vowels for which the distances between sites have decreased the most from the older to the younger generation are the long vowels in lär and lat. The median distance among the older speakers is 1.70 for lär and 1.56 for lat. In the younger age group the median distances are 1.26 (lär) and 1.12 (lat). The role of these vowels as markers of dialectal identity seems to be decreasing the most.

The vowel in the word söt, has a considerably larger median distance in the younger generation than in the older. In the older generation this vowel shows relatively little geographic variation. The median distance for the older speakers is 1.42, and the vowel is at the fourth but last place in the descending list. In the younger generation, the vowel in söt has a median distance of 1.67 and is found at place four from the top of the list, next to lös, which has the same vowel phoneme in Standard Swedish. In the younger generation, three out of the four most varying vowels correspond to the Standard Swedish phoneme /ø/. This seems to be the most prominent regional marker in vowel pronunciation for younger Swedes.

### 6.2.2 Degree of change

In the previous section linguistic distances between sites were calculated in order to measure the geographic variability of each of the vowels. For measuring the degree of change of each vowel, linguistic distances between the two age groups were calculated. For each site, the distance between the older and younger speakers was computed for each vowel using Euclidean distance (Equation 6.1, p. 102). As in the previous section the median was considered the most appropriate measure of central tendency because of the skewed distribution for some of the vowels. Table 6.2 displays the median acoustic distance between the two age groups for each vowel in descending order. The table shows which vowels have changed the most on average.

The vowels that seem to be changing the most are the Swedish long ä and ö vowels. The four vowels that have the highest median difference between older and younger speakers all correspond to å or ö: the vowels in lär, nåt, lös and dör with median distances between 1.60 and 1.85. On the sixth place in the list söt is found with an median difference of 1.52. The short å and ö vowels in särk and dörr show less change. The median age differences of the vowel in särk is 1.02 and of the vowel in dörr 0.97.

Vowels that seem relatively stable, with little difference between the two age groups, are the long and short a in lat and lass and the short vowels in lott and disk. The previous section showed that short vowels vary less geographically than long vowels. The same holds for the variation between the two generations: the long vowels show more change than the short vowels.
Comparing the amount of change between the two age groups per vowel with the amount of geographic variation per vowel in the previous section (Table 6.1) gives some insight into the different types of change in the different vowels. The vowel in lär, which is the vowel that has the largest degree of change (median age difference 1.85), has a moderate amount of geographic variation in the older generation (median distance between sites 1.70), but in the younger generation it is one of the least varying vowels (median distance between sites 1.26). In the case of the lär vowel there is a clear effect of dialect leveling, as the distances between varieties are decreasing.

The ö in dör shows a different pattern. This vowel is the geographically most variable vowel in both age groups (median distance between sites 2.23 for older and 1.88 for younger speakers). Still, the vowel in dör is also one of the vowels that has changed the most (median age difference 1.60). This vowel seems to hold its position as an important dialect marker even though its pronunciation is changing. Also the vowel in nät shows a quite similar amount of geographic variation in both age groups (old 1.61; young 1.45), even though it is changing substantially (median age difference 1.77).

The vowel in sot is the second most variable vowel across sites. This is true for both generations according to Table 6.1. The sot vowel does not show much change between the generations (median age difference 1.14), but seems to be a rather stable dialectal marker.

The vowel in lett only varies to a moderate degree geographically in both generations (old 1.47, young 1.38), but is one of the vowels that has changed the most

### Table 6.2. Median acoustic distance between older and younger speakers for each vowel. The vowels are listed in descending order.

<table>
<thead>
<tr>
<th>vowel</th>
<th>median</th>
</tr>
</thead>
<tbody>
<tr>
<td>lär</td>
<td>[æː]</td>
</tr>
<tr>
<td>nät</td>
<td>/eː/</td>
</tr>
<tr>
<td>lös</td>
<td>/oː/</td>
</tr>
<tr>
<td>dör</td>
<td>[œː]</td>
</tr>
<tr>
<td>lett</td>
<td>/ɛ/</td>
</tr>
<tr>
<td>söt</td>
<td>/oː/</td>
</tr>
<tr>
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<tr>
<td>lus</td>
<td>/uː/</td>
</tr>
<tr>
<td>flytta</td>
<td>/v/</td>
</tr>
<tr>
<td>typ</td>
<td>/yː/</td>
</tr>
<tr>
<td>sot</td>
<td>/uː/</td>
</tr>
<tr>
<td>disk</td>
<td>/i/</td>
</tr>
<tr>
<td>särk</td>
<td>[æ]</td>
</tr>
<tr>
<td>lat</td>
<td>/oː/</td>
</tr>
<tr>
<td>dörr</td>
<td>[œ]</td>
</tr>
<tr>
<td>lott</td>
<td>/ɔ/</td>
</tr>
<tr>
<td>lass</td>
<td>/a/</td>
</tr>
</tbody>
</table>
in addition to the $\ddot{a}$ and $\ddot{o}$ vowels (median age difference 1.57). This suggest that
the vowel is changing in a rather similar way across large parts of the language area.
This is confirmed in § 6.1.6, which showed that the pronunciation of the lett vowel
is more open among younger speakers in general than among older speakers.

6.3 Co-occurring vowel features

According to the data in § 6.1, some vowel features seem to have very similar geo-
graphic and/or generational distributions. For example, the vowels in $d\ddot{o}r$ and $l\ddot{a}r$
show similar patterns of change between the two generations (younger speakers have
a more open pronunciation than older speakers), while the vowels in $sot$ and $typ$
are quite stable across the generations and show similar geographic distribution (South
Swedish diphthongization). In order to quantify and measure the strength of co-
variation between vowel features and to identify the main distribution patterns in
the data, a factor analysis was carried out.

6.3.1 Factor analysis

Factor analysis (FA) is closely related to principal component analysis (PCA, de-
scribed in § 5.1.2). Exactly like PCA, FA reduces a large data set into a smaller
number of loadings and scores, which enable the researcher to identify whether the
variables can be divided into relatively independent subsets (components/factors)
and which of the variables in a data set show similar patterns of variation. Nor-
mally, a researcher chooses to analyze a data set either by means of PCA or by FA.
In the present thesis, however, both methods are used. In Chapter 5 PCA was used
to reduce a filter bank representation of speech samples to two articulatory mean-
ful components. In this section FA is used for analyzing geographic and social
covariation in the PCs of the 19 vowels.

The main difference between FA and PCA is that FA analyzes co-variance, while
PCA analyzes variance. This means that only variance that two or more variables
share is analyzed in FA, while PCA analyzes all variance present in the data set.
This makes FA a more suitable method for identifying co-occurring linguistic fea-
tures. In a comparison of different component methods Leino & Hyvönen (2008)
concluded that FA is the most stable component method for identifying dialect re-
geons, providing easily interpretable results.

Table 6.3 shows a sample of the data used as input for the FA. As in all other
analyses in the present chapter, the data was divided into older and younger speakers
per site, and average values of the acoustic variables were computed for the two
speaker groups per site. FA is more stable without missing values in the analysis than
with missing data. Hence, only speaker groups where all 19 vowels were recorded
were used in the analysis. For the older speaker group the number of sites where all
vowels were recorded was 89 and for the younger group 91. This gave a total of 180
objects (data rows) in the analysis.
Table 6.3. Sample of data for the FA. The objects of the analysis are the two age groups at each site. The objects (180 in total) are represented by average values on the variables of around six speakers per group (three men and three women). The analysis comprises 76 variables: 19 words \(\times\) 4 values (PC1 and PC2 onset, and PC1 and PC2 diphth.).

<table>
<thead>
<tr>
<th>site</th>
<th>speakers</th>
<th>objects variables</th>
<th>variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PC1</td>
<td>PC2</td>
<td>PC1</td>
</tr>
<tr>
<td>Ankarsrum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>old</td>
<td>-0.97</td>
<td>0.23</td>
<td>1.12</td>
</tr>
<tr>
<td>young</td>
<td>-0.74</td>
<td>0.38</td>
<td>0.87</td>
</tr>
<tr>
<td>Anundsjö</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>old</td>
<td>-1.27</td>
<td>-0.08</td>
<td>1.16</td>
</tr>
<tr>
<td>young</td>
<td>-1.21</td>
<td>0.05</td>
<td>1.18</td>
</tr>
<tr>
<td>Arjeplog</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>old</td>
<td>-1.09</td>
<td>0.33</td>
<td>1.18</td>
</tr>
<tr>
<td>young</td>
<td>-1.08</td>
<td>0.11</td>
<td>0.98</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Öxabäck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>old</td>
<td>-1.45</td>
<td>-0.04</td>
<td>0.76</td>
</tr>
<tr>
<td>young</td>
<td>-1.15</td>
<td>0.04</td>
<td>0.73</td>
</tr>
</tbody>
</table>
The variables used in the FA were vowel quality and the degree of diphthongization of each of the 19 vowels. The vowel quality was measured at 25% of the total vowel duration. The amount of diphthongization was calculated as the difference between the vowel quality close to onset (at 25%) and close to offset (at 75% of the total vowel duration). Vowel quality was measured with two acoustic PCs, which lead to a total of 76 variables in the analysis: four acoustic variables (vowel quality at onset and degree of diphthongization, both measured with two PCs) of 19 vowels.

The abstraction of the amount of diphthongization (PC value close to onset minus PC value close to offset) makes it possible to detect vowels that show similar types of diphthongization even if the vowel quality is different. A negative value of diphthongization means that the PC value increases during the vowel segment, and the other way around. In articulatory terms, this means that a negative value of diphthongization on PC1 suggests an opening diphthong, while a positive value of diphthongization on PC1 suggests a closing diphthong. For PC2, the relationship with articulation is not as direct (see § 5.2), but in rough terms, a negative value indicates that the pronunciation becomes fronted during the vowel segment, while a positive value indicates that the vowel changes from a fronted vowel towards the back.

Exactly as PCA, FA can be carried out using a variance-covariance matrix or a correlation matrix. Using a correlation matrix means that all variables have been standardized, that is, transformed into z-scores before the analysis. Standardizing the variables makes sense if variables are measured in different scales or have different ranges. In the present data set the measures of vowel quality at onset and the degree of diphthongization are of different magnitudes. The variance of the degree of diphthongization is generally smaller than that of the vowel quality. Hence, the
6.3. Co-occurring vowel features

FA was carried out on a correlation matrix. With this method, the variance that each variable contributes is 1 and only factors with an eigenvalue greater than 1 are considered important ones, since they contribute more to the analysis than any single variable does. The analysis gave 18 factors with an eigenvalue greater than 1. However, according to Tabachnik & Fidell (2007), using all factors with an eigenvalue greater than 1 is likely to overestimate the number of factors to be extracted if the analysis comprises more than 40 variables. Since the current analysis comprises 76 variables the scree plot was used as an additional method to determine the number of factors. The scree plot (Figure 6.2) does not show any sharp elbow, but after the tenth factor the slope does not change direction radically. Based on the scree plot ten factors were extracted. Varimax rotation (see § 5.1.4) was used for extraction and ten factors explain 60.6% of the total variance in the data.

Table 6.4 shows a sample of the data after reduction by means of FA. Each object is now described by scores on the ten extracted factors instead of by values on the original 76 variables (sample in Table 6.3). In addition to the factor scores, the analysis results in a set of loadings on each factor. The loadings are displayed in Tables 6.5–6.12, and show the degree of correlation between the original variables and each factor. Following Tabachnik & Fidell (2007) loadings above 0.71 are considered excellent, above 0.63 very good and above 0.55 good. Loadings below 0.55 were not analyzed. Because the objects of the analysis are geographic locations and the two speaker groups, each factor clusters vowel features with similar geographic and generational distributions.

Below, the factor scores of each extracted factor are visualized on maps. For each factor there are two maps: one for the older speakers and one for the younger speakers. On the maps the area of each variety is colored in a scale from green to magenta (see Appendix B, § B.3). Green means that the score is low, while magenta indicates a high score. Hence, objects with similar scores have similar colors. Similar scores indicate similar pronunciations of the vowels with high loadings on the factor in question.

In contrast to the maps discussed in § 6.1, these maps cannot be interpreted directly in terms of vowel quality. The maps visualizing the factor scores display solely distribution patterns found in a number of variables. The factor loadings tell which of the vowels are connected to these distribution patterns. Differences in vowel quality among the objects can to some extent be inferred by interpreting the scores and loadings together. Since factor loadings can be interpreted as correlations, a high positive loading indicates that objects with high scores have higher values on the variable in question than objects with low scores, while high negative loadings suggest the opposite.
**Table 6.4.** Result of data reduction by FA. The original 76 variables (that is, four acoustic variables of 19 vowels) have been reduced to scores on ten factors.

<table>
<thead>
<tr>
<th>site</th>
<th>speakers</th>
<th>factor1</th>
<th>factor2</th>
<th>factor3</th>
<th>factor4</th>
<th>factor5</th>
<th>factor6</th>
<th>factor7</th>
<th>factor8</th>
<th>factor9</th>
<th>factor10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankarsrum</td>
<td>old</td>
<td>0.44</td>
<td>0.70</td>
<td>-0.65</td>
<td>-0.22</td>
<td>0.65</td>
<td>1.14</td>
<td>-1.94</td>
<td>0.34</td>
<td>0.33</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>young</td>
<td>0.11</td>
<td>1.34</td>
<td>0.72</td>
<td>-0.96</td>
<td>1.02</td>
<td>0.74</td>
<td>-1.44</td>
<td>-0.86</td>
<td>1.39</td>
<td>0.22</td>
</tr>
<tr>
<td>Anundsjö</td>
<td>old</td>
<td>0.77</td>
<td>-0.50</td>
<td>-1.12</td>
<td>0.42</td>
<td>0.40</td>
<td>-0.17</td>
<td>1.08</td>
<td>0.35</td>
<td>1.16</td>
<td>-0.54</td>
</tr>
<tr>
<td></td>
<td>young</td>
<td>1.16</td>
<td>-0.53</td>
<td>-0.26</td>
<td>0.07</td>
<td>-0.16</td>
<td>0.34</td>
<td>1.00</td>
<td>0.26</td>
<td>-0.27</td>
<td>-0.01</td>
</tr>
<tr>
<td>Arjeplog</td>
<td>old</td>
<td>0.52</td>
<td>0.75</td>
<td>-0.46</td>
<td>-0.52</td>
<td>1.72</td>
<td>1.30</td>
<td>2.07</td>
<td>0.75</td>
<td>0.30</td>
<td>-0.77</td>
</tr>
<tr>
<td></td>
<td>young</td>
<td>0.61</td>
<td>-0.15</td>
<td>0.37</td>
<td>-0.43</td>
<td>0.29</td>
<td>0.83</td>
<td>2.06</td>
<td>-0.39</td>
<td>0.20</td>
<td>-0.78</td>
</tr>
<tr>
<td>Öxabäck</td>
<td>old</td>
<td>-0.30</td>
<td>-0.81</td>
<td>-1.37</td>
<td>1.00</td>
<td>-1.24</td>
<td>0.39</td>
<td>-0.35</td>
<td>0.64</td>
<td>-1.29</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>young</td>
<td>0.52</td>
<td>-0.42</td>
<td>-0.46</td>
<td>0.08</td>
<td>-1.56</td>
<td>1.46</td>
<td>-0.50</td>
<td>1.62</td>
<td>-0.25</td>
<td>-0.10</td>
</tr>
</tbody>
</table>
6.3. Co-occurring vowel features

Table 6.5. High loadings on the first factor (13.5% variance explained).

<table>
<thead>
<tr>
<th>vowel</th>
<th>measure</th>
<th>pc</th>
<th>loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>dis</td>
<td>/iː/</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>flytta</td>
<td>/yi/</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>disk</td>
<td>/i/</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>nät</td>
<td>/ɛː/</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>lett</td>
<td>/ɛ/</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>lösf</td>
<td>/ʊː/</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>typ</td>
<td>/yː/</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>lär</td>
<td>[æː]</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>lus</td>
<td>/uː/</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>söt</td>
<td>/ʊː/</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>särk</td>
<td>[æː]</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>leta</td>
<td>/ɛː/</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>lass</td>
<td>/a/</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>dörr</td>
<td>[œː]</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>lat</td>
<td>/ɑː/</td>
<td>onset</td>
<td>pc2</td>
</tr>
<tr>
<td>dör</td>
<td>[œː]</td>
<td>onset</td>
<td>pc2</td>
</tr>
</tbody>
</table>

6.3.2 Factor 1

The first factor explains 13.5% of the total variance in the data. A number of front vowels show high positive loadings (Table 6.5). For all of these vowels, the high loadings concern the onset value of PC2. Figure 6.3 shows the scores of this factor. The more magenta the coloring on the map, the higher the score.

The positive loadings indicate that objects with high scores have higher PC2 values on the vowels involved than objects with low scores. The maps show that many Svealand varieties and varieties along the Finnish south coast have low scores on this factor (green), while most of the dialects in the rest of the language area have higher scores (magenta). The scores show a relatively stable pattern across the two generations, which indicates that the variables are not involved in any large ongoing change. Lower PC2 values in Svealand and on the Finnish south coast were also noted for most of the front vowels in § 6.1.

As shown in Figure 5.13 (p. 77) the correlation between PC2 and F2 is weaker exactly for the highest F2 values, that is for front vowels. The low PC2 values for front vowels in Svealand and in the south of Finland are therefore not necessarily an effect of retracted pronunciation and lower F2. It is in fact quite unlikely that all front vowels would show a non-maximal F2. That would mean that the whole vowel space would not be used and that there would not be a maximal acoustic distinction between front and back vowels. This would be against the theory of maximal dispersion (Lindblom, 1986).

It is more likely that the low PC2 values in the green area in Figure 6.3 are a result of lower intensity at the highest frequency area in general than of low frequencies of F2. A possible explanation for differences in the intensity at higher frequencies would be differences in voice quality. Less vocal effort and the use of breathy voice
Figure 6.3. Scores of the first factor. Green = low score, magenta = high score. Vowels with high loadings are displayed in Table 6.5. The gradient colors most likely denote differences in spectral slope, which might suggest voice quality differences.

are factors that increase the spectral tilt. When breathy voice is used the vocal folds do not close simultaneously, but they close first at front and never close completely at the back. Hence higher harmonics in the spectrum are attenuated (Klatt & Klatt, 1990, 822–823). The result is a steep spectral slope and little energy in the highest part of the spectrum. Varying the degree of physical effort used for speech production has a similar effect on the spectral tilt (Sluijter & Van Heuven, 1996). In loud speech the glottal pulse is asymmetrical (the closing phase is faster) which increases the intensity of higher harmonics. In softer speech there is less intensity at higher frequencies and the spectral tilt is steeper.

Elert (1983) discusses regional variation in voice quality in Swedish. Based on his own perceived observations Elert mentions that creaky voice is used in Småland while breathy voice can be found land inwards in Norrland. The fundamental frequency is lowest in the north and increases towards the south and reaches a maximum in Västergötland and Östergötland. The area surrounding Stockholm is according to Elert characterized by nasalization. Nasalization of vowels leads to anti-formants in the spectrum as a result of acoustic coupling (Rietveld & Van Heuven, 2009). Some frequencies are reinforced while others are attenuated by nasalization, and the effect on the spectrum varies across vowels.
The conclusion that the first factor of this study is connected to voice quality differences is only speculative and has not been confirmed by other analyses of the data. Regional differences in voice quality should be studied further with instrumental methods. Possible explanations for the low PC2 values in Svealand and Finland are more use of breathy voice or the use of less vocal effort (that is, softer speech) than in Götaland and Norrland, or nasal voice quality.

6.3.3 Factor 2

The second factor correlates with the long close vowels in *typ*, *dis*, *sot* and *lus* (Table 6.6). This concerns the onset value and degree of diphthongization of PC1 of the vowels in *typ*, *dis* and *lus* and PC2 of the *sot* vowel. The factor explains 9.1% of the total variance.

The maps in Figure 6.4 show that the South Swedish varieties clearly differ from the rest on this factor. These varieties have a clear magenta color, which means high scores and indicates higher PC1 values at the onset in the vowels in *typ*, *dis* and *lus* and higher PC2 values in the vowel in *sot* than in the rest of the language area. This suggests a more open pronunciation at onset in *typ*, *dis* and *lus* and a more fronted pronunciation at onset in *sot*.

The loadings related to the degree of diphthongization of these vowels are also positive, which suggests higher diphthongization values for the South Swedish varieties than for the other varieties. As explained in § 6.3.1, positive diphthongization values indicate decreasing PC scores during the vowel segment, while negative diphthongization values indicate increasing PC scores. A diphthongization value close to zero means a monophthong-like pronunciation. Because the diphthongization values can be both positive and negative, the range of the diphthongization values of the objects has to be taken into account when interpreting factor scores connected to diphthongization. The box plots in Figure 6.5 show the dispersion of the variables measuring the amount of diphthongization with high loadings on the second factor. The central box spans values around or slightly above zero for all four variables, which means that most varieties have a monophthong-like pronunciation. All of the four vowels show a number of outliers with high positive values close to 1, and for the *sot* vowel even higher. Since the South Swedish varieties have high positive

<table>
<thead>
<tr>
<th>vowel</th>
<th>measure</th>
<th>pc</th>
<th>loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>typ /y:/</td>
<td>diphth</td>
<td>pc1</td>
<td>0.849</td>
</tr>
<tr>
<td>typ /y:/</td>
<td>onset</td>
<td>pc1</td>
<td>0.843</td>
</tr>
<tr>
<td>dis /i:/</td>
<td>diphth</td>
<td>pc1</td>
<td>0.782</td>
</tr>
<tr>
<td>sot /u:/</td>
<td>onset</td>
<td>pc2</td>
<td>0.767</td>
</tr>
<tr>
<td>dis /i:/</td>
<td>onset</td>
<td>pc1</td>
<td>0.755</td>
</tr>
<tr>
<td>sot /u:/</td>
<td>diphth</td>
<td>pc2</td>
<td>0.706</td>
</tr>
<tr>
<td>lus /u:/</td>
<td>diphth</td>
<td>pc1</td>
<td>0.683</td>
</tr>
<tr>
<td>lus /u:/</td>
<td>onset</td>
<td>pc1</td>
<td>0.583</td>
</tr>
</tbody>
</table>
Chapter 6. Analysis on the variable level

Figure 6.4. Scores of the second factor, which is an indicator of South Swedish diphthongization. Green = low score, magenta = high score. Vowels with high loadings are displayed in Table 6.6.

scores on the second factor, the outliers are likely to be the South Swedish varieties. Positive values of diphthongization on PC1 indicate closing diphthongs, while positive values of diphthongization of PC2 indicate that the vowel changes from a more fronted vowel towards the back. The conclusion can be drawn that the vowels in *typ*, *dis* and *lus* are all closing diphthongs in South Swedish, while the vowel in *sot* moves from a fronted position to the back. This corresponds well to the South Swedish diphthongization described in § 2.3.2.1. Long vowels are pronounced as rising diphthongs that reach the Standard Swedish vowel quality at the end. Front vowels are closing, while back vowels start as central unrounded vowels and move backwards to their Standard Swedish vowel quality. According to Elert (2000, 39), the close vowels are the most strongly diphthongized vowels in South Swedish. The area with the magenta color in Figure 6.4 corresponds well to the area of South Swedish diphthongization described by Elert (2000, 39–40).

Figure 6.6 shows an example of the dynamic change in PC scores during the vowel segments in South Swedish diphthongization. The average scores of the older speakers at the site Norra Rörum at all nine sampling points are displayed for the four vowels. The PC traces show a very regular diphthongization across the vowels.
6.3. Co-occurring vowel features

**Figure 6.5.** Box plots that show the dispersion of the diphthongization values of vowels with high loadings on the second factor: typ (PC1), dis (PC1), lus (PC1), sot (PC2). In order to interpret the high scores of South Swedish varieties on the second factor, it was important to know how high the highest values on the variables involved were. The box plots show that the largest sample values are around 1 for all variables, and that there are a number of outliers with high values.

**Figure 6.6.** As an example of South Swedish diphthongization, the plot shows the average scores at all nine sampling points of the older speakers at one site, Norra Rörum. The vowels with high loadings on the second factor are displayed: typ (PC1), dis (PC1), lus (PC1), sot (PC2). The traces show the regularity of the South Swedish diphthongization across the four vowels.
In the younger generation there are fewer sites with very high scores on the second factor than in the older generation, but magenta-hued colors are found at a number of sites in Götaland and also in Närke. For these sites a relatively open pronunciation of the vowels involved was found in § 6.1.

6.3.4 Factor 3

The third extracted factor explains 8.4% of the variance in the data. Vowel features with high loadings on the third factor are displayed in Table 6.7. Vowels related to this factor are the front mid vowels in the words *lett*, *dör*, *lös*, *söt*, *lär* and *leta*. Figure 6.7, which displays the factor scores of the third factor, shows a large difference between older and younger speakers. The map of the older speakers is dominated by green, which means low factor scores, while the map of the younger speakers is mostly magenta with only a few green spots.

The variation on the third factor concerns the onset value of PC1 of all of the involved vowels. The loadings are all positive, which means that a high score (magenta on the maps) suggests a high PC1 value, while low scores (green) indicate low PC1 values. Interpreted in articulatory terms magenta represents a more open pronunciation of the vowels involved than green. Hence, the pronunciation of these vowels is generally more open among younger speakers than among older speakers.

The fact that younger speakers in general pronounce these vowels more openly than older speakers, was also noted separately for each vowel in § 6.1. However, the different vowels involved show slightly different patterns.

The pronunciation of the vowel in *lett* seems to have become more open in the younger generation in general. The vowel of *leta* also has a more open pronunciation among younger speakers than among older speakers, but in some areas the vowel is a closing diphthong, which means that the PC1 values are high close to onset but decrease towards offset. The closing diphthong is found in South Swedish varieties, on Gotland and among older speakers in Norrbotten.

The vowels in *dör* and *lär*, that is, the pre-/r/ variants of /øː/ and /eː/, have an open pronunciation in the older generation in an eastern area (particularly Uppland, Gotland and Finland) and in the South Swedish varieties. In *dör* also the dialects in Norrbotten have an open pronunciation close to onset, but the vowel is strongly diphthongized. In the younger generation the open pronunciation of the vowels in *dör* and *lär* has spread all over the language area.

<table>
<thead>
<tr>
<th>vowel</th>
<th>measure</th>
<th>pc</th>
<th>loading</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>lett</em></td>
<td>/e:/</td>
<td>onset</td>
<td>pc1</td>
</tr>
<tr>
<td><em>dör</em></td>
<td>[œː]</td>
<td>onset</td>
<td>pc1</td>
</tr>
<tr>
<td><em>lös</em></td>
<td>/øː/</td>
<td>onset</td>
<td>pc1</td>
</tr>
<tr>
<td><em>söt</em></td>
<td>/øː/</td>
<td>onset</td>
<td>pc1</td>
</tr>
<tr>
<td><em>lär</em></td>
<td>[æː]</td>
<td>onset</td>
<td>pc1</td>
</tr>
<tr>
<td><em>leta</em></td>
<td>/eː/</td>
<td>onset</td>
<td>pc1</td>
</tr>
</tbody>
</table>
6.3. Co-occurring vowel features

Figure 6.7. Scores of the third factor. Green = low score, magenta = high score. Vowels with high loadings are displayed in Table 6.7. The large difference between older and younger speakers has to do with the lowering of front mid-vowels by younger speakers.

For the vowels in lös and söt the pattern looks somewhat different. The söt vowel has a quite close pronunciations among most of the older speakers. The open pronunciation in the younger generation has not spread as much as for the vowels in dör and lär, but the most open pronunciations are found in central Sweden and on the west coast. The lös vowel shows a similar distribution as the söt vowel for younger speakers, but among older speakers the lös vowel is diphthongized at many sites, especially in Norrland and on Gotland.

In spite of the somewhat different geographic distributions for the different vowels involved in the third factor, the factor has detected a general trend and collected vowels with higher PC1 values for younger speakers than for older speakers.

6.3.5 Factor 4

On the fourth factor only one vowel has got high loadings: the vowel in dörr. The variation involves the diphthongization of PC1 and somewhat less the vowel quality at onset (Table 6.8). 5.2% of the variance in the data is explained by this factor. The pattern is generationally quite stable. The geographic areas that are identified by this
Table 6.8. High loadings on the fourth factor (5.2% variance explained).

<table>
<thead>
<tr>
<th>vowel</th>
<th>measure</th>
<th>pc</th>
<th>loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>dörr</td>
<td>[œ]</td>
<td>diphth</td>
<td>pc1</td>
</tr>
<tr>
<td>dörr</td>
<td>[œ]</td>
<td>onset</td>
<td>pc1</td>
</tr>
</tbody>
</table>

Figure 6.8. Scores of the fourth factor, which is connected to the pronunciation of the vowel in dörr (see Table 6.8). Green = low score, magenta = high score.

factor are the South Swedish area and the province of Jämtland (Figure 6.8). The loadings are negative, which suggests that variants with high scores (magenta) have a lower diphthongization value. In § 6.1.14 negative diphthongization values on PC1 (that is, an opening diphthong) were found in Jämtland and in the South Swedish area, while most varieties of Swedish do not have a diphthongized pronunciation. In the South Swedish area the vowel starts and ends more open than in Jämtland.

Because only one vowel is involved in the fourth factor, the factor does not contribute much to the detection of co-occurring features. What the factor tells us, is that varieties with a diphthongized pronunciation of the vowel in dörr also have low PC1 values close to onset.
Table 6.9. High loadings on the fifth factor (5.2% variance explained).

<table>
<thead>
<tr>
<th>vowel</th>
<th>measure</th>
<th>pc</th>
<th>loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>sot /u:/</td>
<td>onset</td>
<td>pc1</td>
<td>0.813</td>
</tr>
<tr>
<td>sot /u:/</td>
<td>diphth</td>
<td>pc1</td>
<td>0.758</td>
</tr>
<tr>
<td>lus /u:/</td>
<td>diphth</td>
<td>pc2</td>
<td>0.571</td>
</tr>
</tbody>
</table>

Figure 6.9. Scores of the fifth factor. Green = low score, magenta = high score. The underlying factor is secondary diphthongization of the vowels in sot and lus on Gotland and in Norrbotten (Table 6.9).

6.3.6 Factor 5

The fifth factor identifies two very clear dialect groups: the dialects of Gotland and the dialects in Norrbotten (Figure 6.9). However, on Gotland both older and younger speakers are assigned high scores (magenta), while in Norrbotten the younger speakers have low scores like the rest of the language area. The variation involves the onset value and diphthongization of PC1 of the vowel in sot and to some extent the diphthongization of the vowel in lus (Table 6.9). The fifth factor explains 5.2% of the variance in the data.

Diphthongization of these two vowels on Gotland and among older speakers in Norrbotten was also detected in §§ 6.1.7 and 6.1.19. The type of diphthongization of the vowel in lus was found to vary across the dialects in Norrbotten.
On Gotland, diphthongization of these vowels (so-called secondary diphthongization, see § 2.3.3) is part not only of the local dialects, but also of standard-like speech (see § 2.3.2). On the basis of only this factor no conclusions can, thus, be drawn about whether the Gotlandic speakers speak a traditional dialect or a more leveled standard-like variety.

In Norrbotten diphthongs are characterizing for the traditional dialects. However, in standard-like speech in this area diphthongs are lacking (Johansson, 1982; Elert, 1994). According to Figure 6.9, most of the younger speakers in Norrbotten do not use diphthongs. This feature seems to be leveled and the pronunciation of the vowels is closer to Standard Swedish.

6.3.7 Factor 6

The amount of variance explained by the sixth factor is 4.9%. The vowels with high loadings are the vowels in the words lott, lat and lass (Table 6.10). These vowels have changed very little between the older and younger generation according to the results in the previous section (Table 6.2, p. 105). Also in Figure 6.10, which displays the scores of the sixth factor, the geographic variation pattern looks very

![Figure 6.10. The sixth factor identified small, geographically conditioned differences in the pronunciation of the vowels in lott, lat and lass (see Table 6.10). Green = low score, magenta = high score.](image-url)
similar in the older and younger generation. All of these vowels also show a relatively small amount geographic variation (Table 6.1, p. 103). Apparently, the sixth factor catches relatively subtle differences.

The variation concerns the amount of diphthongization of PC2. For the vowel in lott the loading is excellent, while the vowels of lat and lass have lower loadings. The loadings are positive, which indicates that variants with higher scores (magenta) have higher diphthongization value.

Mainly South Swedish varieties and a number of varieties in Norrland are assigned low scores (green) on this factor. Also the older speakers of some sites in Svealand and on Gotland have low scores, as well as some of the Finland-Swedish varieties. The highest scores are found in Götaland. Differences in the diphthongization of the vowel in lott between varieties Götaland and Norrland were also noted in § 6.1.18.

<table>
<thead>
<tr>
<th>Table 6.10. High loadings on the sixth factor (4.9% variance explained).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>vowel</strong></td>
</tr>
<tr>
<td>lott</td>
</tr>
<tr>
<td>lat</td>
</tr>
<tr>
<td>lass</td>
</tr>
</tbody>
</table>

6.3.8 Factor 7

The amount of diphthongization on PC1 of the vowel in the words läs/låt, nät and lär correlates positively with the seventh factor (Table 6.11), which explains 4.7% of the variance in the data.

The amount of diphthongization of PC1 of läs/låt and nät both have a mean value close to 0 and a standard deviation of 0.3. Low scores (green), hence, indicate negative diphthongization values, while high scores (magenta) suggest positive diphthongization values. The vowel in lär has less variation in the degree of diphthongization, with a mean of −0.1 and a standard deviation of 0.2.

Figure 6.11 shows that the dialects on Gotland have the lowest scores in the older generation, together with some Central Swedish varieties. The low scores suggest opening diphthongs in läs/låt and nät. This is a part of the Gotlandic diphthongization described in § 2.3.2.3.

Eklund & Traunmüller (1997) noted a substantial diphthongization of mid vowels in Standard Swedish, which could fit with the green Central Swedish area in the maps.

<table>
<thead>
<tr>
<th>Table 6.11. High loadings on the seventh factor (4.7% variance explained).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>vowel</strong></td>
</tr>
<tr>
<td>läs/låt</td>
</tr>
<tr>
<td>nät</td>
</tr>
<tr>
<td>lär</td>
</tr>
</tbody>
</table>
Figure 6.11. Scores of the seventh factor, which is primarily determined by the amount of diphthongization of the vowels in *lås/låt* and *nåt* (see Table 6.11). Green = low score, magenta = high score.

High scores (magenta) suggest closing diphthongs in *lås/låt* and *nåt*, while intermediate colors indicate a more monophthong-like pronunciation. Conclusions about the pronunciation in *lår* are harder to draw because of the lower correlation.

In the younger generation the geographic distribution on the seventh factor looks very similar to the older generation, but there are less extreme scores overall.

### 6.3.9 Factor 8

The eighth factor explains 3.7% of the total variance. As Figure 6.12 shows, there is one extreme outlier on the eighth factor. That is the older speakers in Överkalix (Norrbotten). Two vowels have high loadings: the vowels in *lass* and *lat* (Table 6.12). The pronunciation of these vowels in Överkalix is discussed in § 6.1.

Apart from the one outlier, low scores are found for example in the South Swedish area and in Uppland, while Västergötland has very high scores.
6.3. Co-occurring vowel features

Table 6.12. High loadings on the eighth factor (3.7% variance explained).

<table>
<thead>
<tr>
<th>vowel</th>
<th>measure</th>
<th>pc</th>
<th>loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>lass</td>
<td>/a/</td>
<td>onset</td>
<td>pcl</td>
</tr>
<tr>
<td>lat</td>
<td>/aː/</td>
<td>onset</td>
<td>pcl</td>
</tr>
</tbody>
</table>

Figure 6.12. Scores of the eighth factor, connected to the pronunciation of the vowels in lass and lat. Green = low score, magenta = high score.

6.3.10 Factor 9

On the ninth factor not a single variable attained a loading that could be considered good. The highest loading was the one of the onset value of PC2 of the vowel of the word dör, which was 0.504. Nonetheless, 3.1% of the variance in the data is explained by this factor, and some geographic areas can be identified in the maps in Figure 6.13.

In the older generation the dialects of Jämtland have very high scores (magenta), while east Svealand is assigned the lowest scores together with sites on the Finnish south coast. In the younger generation, the varieties are not assigned as extreme scores as in the older generation. The east Svealand dialects are more similar to the surrounding area in the younger generation than in the older generation. In Finland, low scores are maintained in the younger generation. The dialects of Norrbotten are very different from each other in the older generation, but the younger speakers in this area are assigned very similar scores.
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Figure 6.13. Scores of the ninth factor. Green = low score, magenta = high score. No variables obtained loadings $\geq 0.55$

6.3.11 Factor 10

On the tenth factor only one variable has a good correlation: the amount of diphthongization on PC2 of the vowel in lős (0.577). The amount of variance explained is 2.9%. In Figure 6.14, the most extreme low scores (green) on this factor are found on Gotland and the most extreme high scores (magenta) are found in Kalix and Nederlulå (Norrland). Dialects in both these areas are known to have preserved Proto-Nordic diphthongs, like the one in lős (see § 2.3.3). Still, the pronunciation in these two areas is different according to the factor scores. The diphthongization on PC2 in Kalix and Nederhuleå is mentioned in § 6.1.12. For the Gotlandic varieties, no large difference between the vowels in söt and lős was found in § 6.1, but diphthongization of Standard Swedish /ø:/ was detected on Gotland.

In Gotland the scores on the tenth factor are similar in the older and younger generation. In Norrbotten there has been a dramatic change between the two generations.
6.4 Summary

In this chapter the geographic variation and age related variation in the 19 different vowels in the data set were analyzed. A detailed view of the variation in each vowel was given in § 6.1, while the amount of geographic and age related variation across the 19 vowels was compared quantitatively in § 6.2. In a factor analysis (FA, § 6.3), the variance in the data set was reduced into ten underlying factors. The three different methods applied in this chapter supplement each other. The quantitative comparison in § 6.2 and the FA in § 6.3 detect vowels and variables which show similar kinds of variation and, hence, summarize the data. The analysis per vowel in § 6.1 gives a detailed account for the variation beyond the comprehensive patterns detected by the two other analyses.

The comparison of the amount of variation on the 19 different vowels, in § 6.2, showed that long vowels vary more than short vowels both across sites and across the two age groups. The two geographically most varying vowels in both age groups were the vowels in dör (Standard Swedish [œ:]) and sot /u:/, while the geographically least varying vowels were the vowels in disk /i/, lass /a/ and särk [æ]. Almost all vowels vary geographically less in the younger speaker group than in the older. The average linguistic distance between dialects is significantly shorter in the younger

\[\text{Figure 6.14. Scores of the tenth factor. Green = low score, magenta = high score. Vowel with high loading: lös.}\]
Chapter 6. Analysis on the variable level

speaker group than in the older speaker group. The linguistic distances becoming shorter indicates an ongoing dialect leveling in the Swedish language area. The vowels with the most decrease in geographic variation were the vowels in lär [æː] and lat /æː/. Only the vowel in söt /øː/ showed considerably more geographic variation among younger speakers than in the older age group.

Some of the factors in the FA identified distinct dialect groups in the data, while others showed a more continuous distribution of the vowel features. Some dialect areas were identified by a number of the extracted factors. For example, the first and the ninth factor showed a relationship between dialects in Svealand and the dialects along the Finnish south coast. The dialects on Gotland were shown by several factors to share some vowel features that distinguish them from the other Swedish dialects (factors three, five, seven and ten). The second factor showed that the most distinguishing feature of South Swedish is the diphthongization of long close vowels. A number of factors also identified distinguishing features for the dialects in Norrland. Especially in the provinces Jämtland (factors three, four and nine) and Norrbotten (factors three, five and ten) divergent dialects are found among the older speakers.

Factors seven and nine showed similar geographical distribution patterns in the older and younger generation of speakers, but among the younger speakers the factor scores were less extreme. These factors might either show that a lower number of the younger speakers than of the older use the dialectal features (that is, some of the younger speakers at a site use the standard variant and others the local variant which gives less extreme average values than for older speakers), or that the dialectal markers are maintained by younger speakers but the acoustic distances between the variants are becoming smaller.

Some factors failed to bundle together features of several vowels, but only correlated highly with one of the vowels in the data set. For example, factor four only correlated highly with the vowel in the word dörr and showed that the vowel quality close to the onset of this vowel is connected to the amount of diphthongization.

The eighth factor identified one outlier in the data set. It showed the older speakers in Överkalix have a divergent pronunciation of the vowels in lass and lat.

The sixth factor showed that the vowels in lott, lat and lass co-occur when it comes to the amount of diphthongization. However, the analyses in §§ 6.1 and 6.2 showed that the total amount of variation in these vowels is very small.

The Swedish front mid vowels showed most variation across the two age groups. The vowels in the words lär [æː], nät /ɛː/, lös /ɔː/, dör [œː], lett /ɛː/, söt /øː/ and leta /ɛː/ were found to have the largest average distances between older and younger speakers in § 6.2. All of these vowels, except for the vowel in nät, were also found to co-occur by the third factor of the FA. This suggests that the change in the vowel in nät has a different distribution than that in the other vowels. The FA showed that what these vowels have in common is that the PC1 values are higher among younger speakers than among older speakers, which means that the pronunciation is becoming more open. The results in § 6.1 showed that the vowels in lär, nät and lett are becoming more open in almost the whole Swedish language area. For the
vowel in dör a more close pronunciation is preserved only in western parts, while the opening of the vowel in lös and söt is restricted to a smaller area in central Sweden and on the west coast.

The change towards a more open pronunciation of the vowels in lär and dör, means a change in the direction of the standard language and varieties spoken around Stockholm. In the case of nät, however, the varieties around Stockholm (together with other eastern varieties) have the most close pronunciation in the older generation and the varieties around Stockholm are the ones that are changing the most. The close pronunciation of the nät vowel in Stockholm (due to a merger of /e:/ and /ɛː/) has never been accepted as Standard Swedish (Elert, 2000, 47).

The spreading of a more open pronunciation of the vowels in söt and lös (Standard Swedish /øː/) is described by Nordberg (1975) as a change from below (see § 6.1.11). The open variant has previously been stigmatized and used mainly by speakers in the lower social classes. In Nordberg’s study, however, open variants were more common among younger speakers than among older speakers, and were used also by higher social class youth. In an FA of a number of dialectal features in the spoken language of Eskilstuna, Hammermo (1989) showed that there was a co-variation between /ɔː/ and /ɛː/. The open pronunciation of these vowels was interpreted by Hammermo as a marker of local identification with Eskilstuna. Other features that co-varied to some extent with these vowels were the pronunciation of /ʊː/ and the degree of Central Swedish diphthongization (§ 2.3.2.2). In Hammermo’s data young girls used more open variants of /ɔː/ and /ɛː/ than young boys. Aniansson (1996) analyzed the same data as Hammermo (1989) and made the interpretation that the open variants were not seen as local markers by the girls, but had become the more prestigious pronunciation. A similar trend was shown by Kotsinas (1994), who described the diffusion of the previously stigmatized open pronunciation of these vowels to Stockholm, where girls, not least in the upper-class, exceeded boys in the use of open variants.

The impact of the lowering of /ɔː/ and /ɛː/ on a large part of the language area is shown very clearly in the analyses in this chapter. Also for the speakers who represent Standard Swedish this ongoing change could be noted. The formerly stigmatized variants, hence, seem to be becoming the preferred variants. Milroy, Milroy, & Hartley (1994) described a case where female speakers starting to use a previously stigmatized feature (glottalization) in British English led to the feature gaining prestige. They suggested that women create prestige instead of being the ones adapting the most to the standard language, which has been postulated in many other studies. This hypothesis fits very well with the Swedish data. In the studies by Hammermo (1989), Kotsinas (1994) and Aniansson (1996), young girls were the ones favoring previously stigmatized open pronunciations of /ɔː/ and /ɛː/. Comparison of older and younger speakers in the present study shows the diffusion of the open pronunciation to a large number of rural Swedish sites, and even to speakers considered representatives of Standard Swedish.