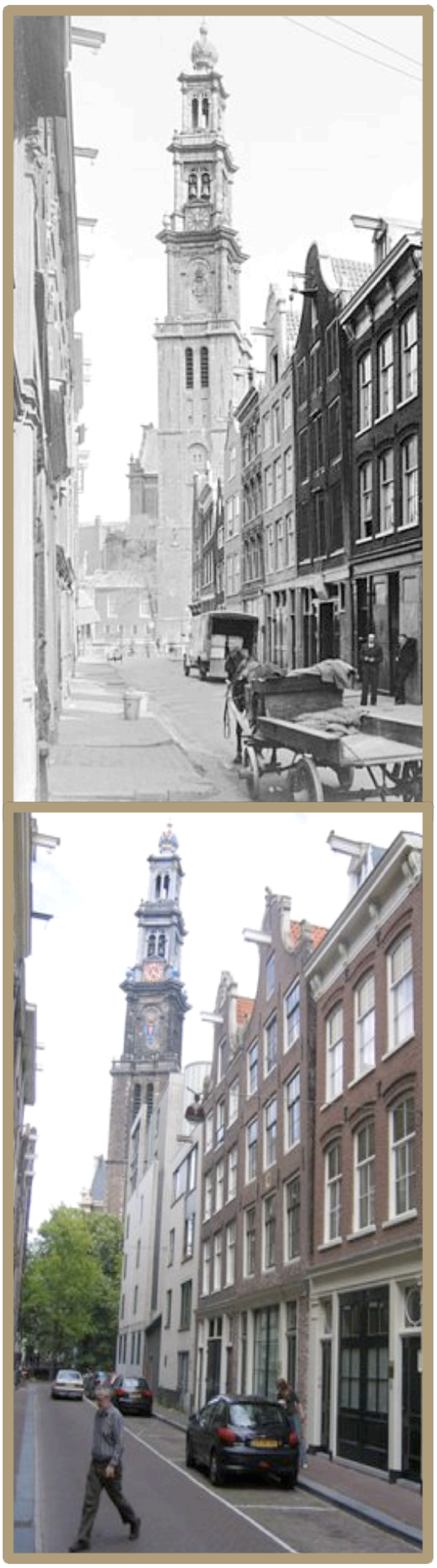

“Jordanese” then and now

A diachronic study of Jordanese Dutch vowels.

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August 31st 2009
University of Amsterdam

INDEX:

The images on the front page were taken from the internet:

Old Jordaan:

http://beeldbank.amsterdam.nl/index.php?&qtype=nieuw&option=com_result&Itemid=9&e5e55c7b130d5340ae830e9829b579de=4e907f697e1ff7cd9fb2592581d3bef8&p=2 (Retrieved on 21/8/2009)

Modern Jordaan:

http://spinoza.blogse.nl/log/spinoza-tentoonstelling-libertas-philosophandi-in-de-bph.html (Retrieved on 21/8/2009)

ABSTRACT

Language is an even evolving phenomenon. A variety of factors may have led to changes in the language of the Jordaan in Amsterdam, such as changes in the community or simply the passing of time. This investigation is aimed at examining the vowels of the language variety of the Jordaan. Four recordings from 1944 and 1945 were compared to five recordings from 2009 to see if there were differences in the pronunciation of vowels by the nine male participants. Results showed that there weren't many differences between the 1944 group and the 2009 group, but the results did suggest that several vowels may have changed over time. The diphthongs /au/ and /ij/ show different pronunciations for the groups, caused by a shift in formant values. Another difference is found in the number of allophones; the 1944 group appears to have more allophones, which becomes apparent in the pronunciations of /eu/ and /ui/. This study is small in scale, but it suggests that further research into this topic may yield some definite changes in the pronunciation of vowels of Jordanese between 1944 and the present day.

1. INTRODUCTION

This chapter will first provide some background information on the neighbourhood Jordaan and its inhabitants. Then the previous research into the Jordanese dialect will be discussed, a comparison to Standard Dutch will be made and finally the research questions and hypotheses will be posed.

1.1 Background information

In this section some background information will be provided about the topic of this thesis; the language variety 'Jordanese'. This is spoken in the neighbourhood Jordaan in city of Amsterdam, in the Netherlands.

1.1.1 Origins of the neighbourhood

This thesis is about the pronunciation of vowels in a variety of Dutch that is locally referred to as 'Jordanees'. For lack of a better term, an anglicized version of this word will be adopted; the language variety that is spoken in the Jordaan will be referred to as 'Jordanese'. The term 'Jordanees' can be used to denominate both the language and its speakers and it is derived from the name of the neighbourhood: Jordaan. This neighbourhood is located to the west of the centre of Amsterdam. Originally built for the growing community of labourers in the 17th century, its inhabitants have been working class people for centuries. The names of many streets refer to the guilds that resided in the neighbourhood. In the 1970's renovations took place on a large scale, to improve the state of the deteriorated buildings. The renovations caused the property prices to rise, making them too expensive for many of the original inhabitants, who relocated to other (cheaper) towns in the province, such as Purmerend and Almere. More wealthy people took up residence in the new buildings, making the population mixed, as it still is today (www.jordaaninfo.nl).

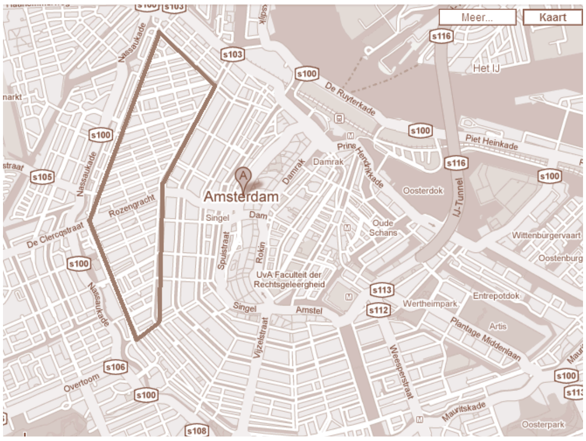

Figure 1: Map of Amsterdam with the neighborhood Jordaan outlined (maps.google.com)

1.1.2 Origins of the language variety

Lexicon

In the 17th century Amsterdam was one of the most important port cities in the western world, so it attracted workers from many places in Holland as well as neighbouring countries (Belgium and Germany). Most of the inhabitants of the Jordaan were textile workers, leather workers or ceramists. Each of these groups lived in their own part of the neighbourhood. There was also a large community of Portuguese Jews in Amsterdam, who had fled from Antwerp after this city fell into the hands of the Spanish army in 1585. The craftsmen from the Jordaan came into contact with them at the markets, where many Jewish merchants (Berns 2009) did business. The contact with the Jews had a large influence on the lexicon of the Jordanese language variety. The Jews spoke Yiddish, a language that evolved from German when the Jewish community migrated to Germany. It has many Hebrew words in the lexicon. Many of these Yiddish words were subsequently incorporated into the Jordanese language, a trait for which it is most known today. Most of those words are no longer used, but some examples can still be found. These are often used throughout Amsterdam and some are even used nation wide. Words such as *jatten* ('to steal'), *mesjogge* ('crazy') and *bonje* ('quarrel') are used or at least understood throughout the Netherlands. Other words, like *achenebbisj* ('shabby') and *majem* ('water' or 'jenever') are considered to be typical of Amsterdam, although Stroop (1999) indicates that it is difficult to determine which words are typical for Amsterdam and which are part of Standard Dutch, because the dialect of Amsterdam is very well known throughout the Netherlands (for example because of its use in television shows).

Phonetics

The characteristic 'thick' pronunciation of /n/ and /l/ (which were interpreted here as [ɲ] and [ɫ]) is said to have come from Haarlem, a city in the province of Noord-Holland (Winkler 1874). The origin of the 'o'-like pronunciation of the long [a:] (which we interpreted as [ɐ]) is not specifically mentioned in any of the previous studies into the subject (see §1.3), but it may possibly have been adopted from the Jewish community (Martens 2006).

1.2 Previous research

The earliest known publication about the dialects of Amsterdam is that of Johan Winkler, who published a work about the dialects in the northern Netherlands in 1874. He reported no less than 19 dialects in Amsterdam, one of which was Jordanese. Its characteristics were a 'thick' /n/ and /l/ ([ɲ] and [ɫ] respectively), the /ui/ was pronounced as [ɔi] and short vowels were palatalized before /d/ and /t/ and /n/.

However, this study by Winkler received some criticism. Van Lennep & Alberdingk Thijm (1877) criticized it because no explanation was given for the division into 19 dialects and they believed there weren't that many dialects in Amsterdam. Van Lennep stated that he didn't distinguish between the dialects of Kattenburg, Haarlemmerdijk en Jordaan for example, because these are very similar and he found no evidence that they are different language varieties. The research that van Lennep & Alberdingk Thijm (1877) carried out themselves was based on a questionnaire of 28 questions that was distributed amongst inhabitants of Amsterdam, asking them about the pronunciation of certain sounds in given contexts and about special expressions. They found among other things that the long /aa/ was either pronounced /ao/ or /ae/ (which we interpreted as [ɐ] and [æ]), the short /a/ was either very short or palatalized. The long vowels /ee/ and /oo/ were diphthongized (to [ei] and [ou]). The /ij/ and /ei/ were pronounced identically, but a number of different ways to pronounce them were reported; [a:i], [a:] and [ɛ:]. The /ie/ was diphthongized by the Jordanese participants when it appeared in words ending in /l/ or /n/: /tien/ was pronounced [tiən] for example.

Jo Daan contributed to the Reeks Nederlands(ch)e Dialectatlassen (a series of atlasses of Dutch dialects) by composing a map of the dialects of Noord-Holland. It comes with a booklet (Daan&Blok 1969) that provides background information about the realization of this atlas of Noord-Holland. Daan used one spokesman from the Jordaan, Willem Bruijn. This is suspected to be the same Willem Bruijn as in the recording used for the present investigation (see §2.1.2), it may even be the same recording.

In 1987, Henriëtte Schatz published a book, *Lik op stuk : het dialect van Amsterdam,* about dialectology in general and the dialect of Amsterdam in specific. About the pronunciation of vowels, she says that the short /a/ and /e/ are pronounced almost like /e/ and /i/, probably under the influence of an ensuing [n], [s] or [t]. For example, /pan/ is pronounced almost like [pɛn] and /pen/ like [pɪn]. This is the palatalization that Winkler already reported in 1874. The long /a/ is often pronounced more as /o/ in words such as 'baas' and 'kaas', making them sound more like [boas] and [koas] (the sound that is interpreted here as [ɐ]). Another reported pronunciation of the long /a/ is a nasalized version, [ã]. After researching this difference Schatz concluded that the first pronunciation, [ɐ], is used by male speakers and the second pronunciation, [ã], is used by female speakers (Schatz 1986). Another remark concerning long vowels is that the long vowels /ee/, /oo/ and /eu/ are often diphthongized ([ei], [ou] and [øy]), while the diphthongs /ui/ and /ij/ are monophthongized (the /ui/ is most likely [œ] and the /ij/ could be [ɛ], [æ] or [a:]).

In 1992 Jan Berns published a book which is an adapted reprint of *Hij zeit wat. Grepen uit de Amsterdamse volkstaal* by Daan (1948). Berns altered very little, but did add new studies and a chapter on the origins of the name Amsterdam. Regarding pronunciation, the findings of Van Lennep&Alberdingk Thijm have been reaffirmed; the short /a/ is palatalized before [n], [s] or [t], the long /aa/ has an [ɔ]-like quality ([ɐ]), /ee/ and /oo/ are diphthongized to [ei] and [ou], /ij/ and /ei/ are pronounced as [a:] or [ɛ:]. However, Daan reported that the latter of these pronunciations was found mostly in Amsterdam-West.

In *Gender variation in Dutch: a sociolinguistic study of Amsterdam speech,* Dédé Brouwer (1989) investigated the "[…] speech differences between women and men, focusing on pronunciation". She found that women predominantly use standard language and men speak more often in their dialect. This might be attributed to the social bias against dialect combined with the social status of women, making the use of dialect by women doubly stigmatized.

Amsterdams by Berns and Van den Braak provides much of the same information as *Hij zeit wat* by Berns in regard to the pronunciation of the dialect of Amsterdam. It treats the sounds of the 17th century at the hand of an article by Commandeur in *Taal&Tongval* (1989), who found that /ee/ was mostly [i] in open syllables, but [ø] when it was a ‘stretched’ (long) /ee/. The long /oo/ was often palatalized to [ø] and there was still a difference between two types of /aa/; one that had always been long and another that originated from a short /a/ in an open syllable. That difference had disappeared in Standard Dutch, but not in Amsterdam, where the originally long /aa/ was pronounced as [æ]. For the 19th century the questionnaire by van Lennep & Alberdingk Thijm (1877) is cited (see above). A novel by Nescio is cited to report the pronunciation of /ij/ around the year 1900, which was [a:]. For the modern language of Amsterdam Berns and van der Braak cite Daan (1969), Mittelmeijer (1959) and Schatz (1986 and 1987), giving the same details about the vowels as described above.

1.3 Standard Dutch vs. Jordanese Dutch

LAX MONOPH-THONGS	EXAMPLE (DUTCH)	TENSE MONOPH-THONGS	EXAMPLE (DUTCH)	DIPHTHONGS	EXAMPLE (DUTCH)
[ɑ]	lat	[a]	laat	[ɑu]	koud
[ɛ]	leg	[e]	leeg	[œy]	huis
[ɪ]	lip	[i]	liep	[ɛi]	wijs
[ɔ]	bom	[o]	boom		
[ʏ]	put	[y]	buur		
[ə]	gelijk	[u]	boek		
		[ø]	deuk		

Table 1: The Standard Dutch vowel inventory (van Son 2000).Vowels are written in IPA, the examples are written according to Dutch orthography.

In Standard Dutch there are 16 vowels: 13 monophthongs and 3 diphthongs (van Son 2000). There are also some allophones in Dutch, but these are not viewed as belonging to the standard variety and will not be described here.

From the results of the previous research into the Jordanese language variety, it can be concluded that Jordanese deviates from Standard Dutch in the pronunciation of at least a few of the vowels: the long [a:] is pronounced with an ‘o’-like quality: [ɐ] (van Lennep & Alberdingk Thijm 1877, Schatz 1986/1987, Berns 1992). The short vowels [ɑ] and [ɛ] are nasalized when followed [n], [s] or [t] (Schatz 1987). At the end of the 19th century the long vowels [e:] and [o:] were diphthongized to [ei] and [ou]. The long [i:] was diphthongized to [iə] in monosyllabic words that end in [l] or [n]. The [ɛi] was pronounced in three different ways; [a:i], [a:] and [ɛ:] towards the end of the 19th century (van Lennep & Alberdingk Thijm 1877), but around 1900 it was pronounced [a:] (Berns & van den Braak 2002). Towards the end of the 20th century it was a monophthong (Schatz 1987).

If all of these pronunciations are found in the 1944 group and are still present in the Jordanese of 2009, the overview of the vowel inventories of both groups of participants in the current investigation would look as follows:

LAX MONOPHTHONGS	EXAMPLE (DUTCH)	TENSE MONOPHTHONGS	EXAMPLE (DUTCH)	DIPHTHONGS	EXAMPLE (DUTCH)
[ɑ]	lap	[ɐ]	laat	[ɑu]	koud
[ɑ̣]	lat	[i]	liep	[ɛi]	wijs
[ɛ]	bel	[y]	buur	[ei]	leeg
[ɛ̣]	pen	[u]	boek	[œy]	huis
[ɪ]	lip	[ø]	deuk	[ou]	boom
[ɔ]	bom				
[ʏ]	put				
[ə]	gelijk				

Table 2: Predicted vowels inventory of Jordanese, based on the previous research into the language variety

1.4 Research questions and hypotheses

The neighbourhood Jordaan has changed a lot over the last decades and it is reasonable to assume that the language spoken there changed accordingly. The goal of this investigation is to determine if and how the pronunciation of vowels in the Jordanese dialect has changed since 1944.

General research question: Has the pronunciation of vowels in Jordanese Dutch changed since 1944?

Language is an ever evolving system; hence it is very likely to have changed in the 65 years that have passed since the recordings of 1944 were made. This investigation is focussed on finding the changes that may have occurred in the vowels, either in the vowel inventory or in the vowel quality.

- Sub question 1: Is the vowel inventory of the 2009 group different from that of the 1944 group?

The vowels that are used by the speakers may have changed, in number or form. A comparison of the pronunciation of all vowels in similar contexts will provide an answer to this research question. This will be done by listening to the recordings and labeling the vowels (see §2.2.1).

- Sub question 2: Has the vowel quality changed; do the vowels of 2009 have different formant values from the 1944 vowels?

The pronunciation of vowels may have changed. This is of course linked to the previous question, because if the formants don't change the vowel inventory isn't changing either. To establish whether the vowel inventory has changed, analyses of the formants and band filters of the vowels will be carried out to provide insight into this matter.

Formants are the frequencies of which the sound waves of speech are built up. The frequencies correspond to the resonation of parts of the vocal tract. There is one formant approximately every 1000 Hz. Each vowel has its own signature set of formant frequencies, making it sound different from the other vowels. In this study, the first 2 formants (F1 and F2) will be investigated, because these are the formants that are most important for identifying vowels. Besides that, using only two formants allows for making visual images of the vowel space in two dimensions.

The formant and band filter analyses will be carried out with the help of the computer program Praat (Boersma & Weenink 2009, see §2.2.2).

2. Methods of investigation

This chapter aims at providing insight into the methods that were used to gather and analyse the data. Section 1 describes the methods of gathering participants and recordings. In section 2, the analysis of the data is discussed.

2.1 Participants and recordings

In total, 9 participant recordings were used for this research. Three of those are from 1944, one is from 1945. These four recordings were found in a historical database (§2.1.2) and will be called the '1944 recordings' or '1944 group' from here on. The remaining five recordings were made in April 2009 and will be called the '2009 recordings' or '2009 group'. To ensure that the privacy of the participants isn't violated, codes will be used to identify the different speakers. These codes start with two digits that indicate the year of recording. These are followed by the first letter of the family name of the participant. In the case of the recordings that were made in 2009 the last two digits of the year of birth were added, because two of the participants have a family name that starts with 'S'. For example: 09M45 was recorded in 2009, his family name starts with 'M' and he was born in 1945.

2.1.1 2009 recordings

The new participant recordings were made in April 2009. To find participants, I brought an acquaintance with me because I found that people tended to be less reserved when they were addressed by two people instead of just one. On the first day we asked people directly if they wanted to participate, but this didn't work well: none of them agreed. Therefore the strategy was adapted; people were asked instead if they knew of a place where willing participants might be found. This worked a lot better; it resulted in recordings of 6 male and 3 female participants. Because there were no female participants in the old recordings, only five recordings of male participants were used in this investigation: 09S45, 09H32, 09M45, 09S43 and 09B36. The recording of the sixth male participant was excluded because it was accidentally cut off half way through.

The first four recordings that were used were recorded in a neighbourhood centre for senior citizens. 09S45 was a bartender, the other 3 were visitors. The establishment consisted of a large room with several tables and a bar. People were playing cards and talking to each other.

The participants were asked if they would agree to being recorded. An explanation was given about the procedure of recording and the recorder and microphone were shown to them. When they agreed to cooperate, they were instructed to read a list of words and sentences, which were taken from the 1944 recordings (Appendix 1). In those recordings, participants 45B and 44B read these same words and sentences and some additional words and sentences, which were left out to produce a list that is as short as possible, while still covering all possible vowels in Dutch. The participants were given a copy of the list and were instructed to read the words in the correct order (per column from top to bottom, left to right). The role of the instructor was limited to informing the participants about what they needed to do and occasionally participating in a conversation with them. See §2.1.3 for more detailed descriptions of the recordings.

2.1.2 1944 recordings

The old participant recordings from 1944 and 1945 were found in the archives of the University of Amsterdam (the historical IFA-corpus). This corpus contains many recordings that have been made by researchers at the university through time. The recordings that were selected for this investigation have been made on glass plates, which cause a clicking sound that is audible throughout the entire recording. Otherwise the quality of the recordings is very reasonable. Four recordings were selected for this research; 45B, 44B, 44T and 44P. The first of these, 45B, has the same name as a participant that Jo Daan recorded for her research into the dialects of Noord-Holland (Daan & Blok 1969). Although the researcher isn’t named in the IFA-corpus, there is reason to believe that the recording of 45B is the one that Daan made. The recording was made 24 years before the atlas was published (which is early but does not provide grounds to rule out the possibility) and the name and origin (the Jordaan) of the participants coincide.

Unfortunately, the origin of the other three participants from 1944 in this investigation is unknown. In the list of glass plate recordings of the IFA corpus they are listed as Jordanese, recorded on April 3rd 1944, but there is no reference to the researcher who made the recordings. See §2.1.3 for more detailed descriptions of the recordings.

2.1.3 Informant details

09S45

Participant 09S45 is a bartender at the establishment. He was recorded standing at the bar at a time when there were about fifteen other people in the room. The conversations between those people are audible in the recording, but due to the directional microphone, the participants’ voice is more prominent. He spoke relatively fast at the beginning, slowing down when he was reading the sentences. Since he was supposed to tend bar, he had no time to have a conversation that could be recorded, so only the list of words and sentences was recorded.

09H32

This participant was recorded in the backyard of the establishment. At the time there was nobody else present there. As a result, the only audible background noise is the chirping of birds. The participant was very friendly and willing to talk, so some conversation has also been recorded. Between reading the words and the sentences he was urged to speak as natural as possible, because he was speaking more formally than he was before he started reading the list of words. After that, when he was reading the sentences aloud, he spoke more naturally.

09M45

Participant 09M45 was recorded inside, sitting at a table. 09S43 was sitting at the same table and there were about twenty other people in the room. The conversations between the other people were louder than they were during the recording of 09S45. The head mounted microphone didn't fit the participant very well, the head of the microphone pointed forward instead of at his mouth. As a result of this, there is more background noise in the recording. The participant made some remarks during the recording, joking about some of the sentences. He also adapted some of them to make them into a joke, saying for instance "Ja meid, melk het schaap met de vijf poten." (*Yes, maid, milk the sheep with five feet.*) instead of "Ja, de meid melkt het schaap om vijf uur." (*Yes, the maid milks the sheep at five o'clock.*)

09S43

This participant was recorded at the same table, right after 09M45. There was a lot of background noise. He read the words quite fast, but slowed down when reading the sentences. He too made some joking remarks about the sentences, but didn't alter any of them.

09B36

Participant 09B36 was recorded on his doorstep in a quiet street. Some faint noises from a nearby playground can be heard in the background. He read the list quite fast and made no additional remarks other than adding a few words during the last sentence ("De nieuwe jas die is van je broer en die is te nauw." instead of "De nieuwe jas van je broer is te nauw.") A salient aspect of his pronunciation is that of /w/ as a bilabial [w] and not the more common labiodental [ʋ].

45B

Participant 45B was recorded in 1945; he was 69 at that time. The recording was made on glass panel and there are no background noises. There is a woman present who asks the participant questions, she could be Jo Daan, who used this recording for her atlas of dialects (1969). There has been some critique on the pronunciation of this participant, it is said to be a bit exaggerated (Mittelmeijer 1959). Especially the authenticity of the pronunciation of /sch/ as [sk] is questioned, as Mittelmeijer didn't find much evidence of that in other speakers.

During the first part of the recording he reads a list of words that is very similar to the one that participant 44B reads (see below). Subsequently a woman interviews the participant. He is given a set of pictures and is asked to describe what he sees. In the last part, he sings a lullaby in three different ways; one as a mother from the Keizersgracht (a high class part of Amsterdam), once as a mother from the Jordaan and finally once as a mother from the 'Jodenhoek' (the former Jewish neighbourhood).

A remarkable detail of his pronunciation is that he mispronounces some of the words that have syllables ending in /-r/, for example in the case of 'weer' and 'deuren'. These words reflect an irregularity in the pronunciation of written language: normally /ee/ is pronounced as [e] (or [ei]), but under the influence of the ensuing /r/ the pronunciation changes to [ɪː]. The same principle applies to /oo/ and /eu/, which change to respectively [ɔː] and [ʏː].

44P

Participant 44P was recorded in 1944. He is interviewed by a woman who asks him questions and he is asked to describe some pictures. At some points he doesn't articulate very well and speaks very softly, which made it difficult at times to transcribe what he is saying.

44B

Participant 44B was recorded in 1944. He reads a list of words and sentences on which the list for the 2009-participants was based. There are some inconsistencies in his pronunciation, which might be caused by the fact that he is reading the words and the formal setting. For example, he pronounces /v/ as [v] in some cases -mostly in the list of words-, as [f] in others -mostly in the sentences-. His speech sounds quite formal in the first part (the words), then becomes more informal during the sentences, so it seems that his pronunciation is influenced by the formality of the setting.

44T

Participant 44T was also recorded in 1944. He is being interviewed in the same way as participant 45B; he is asked to describe a number of pictures. His speech is quite formal in the first part of the recording. In the second part (from time 110s) his sentences get a bit longer and his speech sounds more 'colloquial'. He inserts a 'schwa' between consonants in words such as 'kerk' [kerək].

2.2 Methods of analysis

The recordings of the 2009-participants were downloaded from the recording device onto a computer. They were saved in a folder as individual files in .WAV format. The files of the female recordings were saved in a different folder, because they would not be used in this investigation. The recordings of the remaining 6 male participants were carefully listened to several times, to make sure that they were suitable for use in this investigation. One of the recordings had accidentally been cut off in the middle of the conversation, so it was removed from the investigation. This brought the total of participants from 2009 in this investigation to 5.

The recordings of the 1944-group were downloaded into the same directory as the 2009 group. They were also listened to, in order to make sure that they are suitable for this investigation. All four recordings were of reasonable quality (although there is a persistent crackling noise from the glass plate throughout the recording).

2.2.1 Labelling

The first step in analyzing the recordings was to annotate where each word and each vowel starts and ends. This was done in Praat by creating a "TextGrid", a feature that makes it possible to place textual marks (labels) and boundaries that correspond to the sound. These boundaries were placed according to the rules in the labelling protocol of the *Corpus Gesproken Nederlands* ('Corpus Spoken Dutch', van Son 2000). The labels were placed manually between the boundaries of each word and each vowel.

In the TextGrid three tiers were created:

1. *Vowels*: this tier was used for labelling each vowel with the International Phonetic Alphabet.
2. *Words*: this tier was created for labelling each word using Dutch spelling rules.
3. *Other speakers*: this tier was used to label the utterances that were not made by the participant. The entire utterance was placed between boundaries and transcribed with Dutch orthography.

The waveform, spectrum, pitch and formants were made visible during labelling to be able to determine where the boundaries should be. For this purpose the spectrum and waveform were the most important tools, the formants and pitch were used in case of doubt to help verify the position of the boundary. When opening the window for labelling, Praat shows a large part of the sound. In order to place the boundaries accurately, a single word was selected (including a bit of space on either side).

This selection was zoomed in on and the following steps were executed:

1. Selecting the entire word based on waveform and sound or the entire vowel based on the spectrum, formants and sound.
2. Placing boundaries and moving them to zero-crossings.
3. Listening to the word or vowel and the parts surrounding it to confirm that the boundaries were placed correctly.

Difficulties with labeling

Placing the boundaries exactly at the start and end of a vowel or word is very difficult at times, because it is not always clear where one sound ends and the next starts. When a word ends in [s] and the next word starts with that same sound, for example, the boundary was placed in the middle of the [s] so that both words would have at least a little bit of [s].

With a gradient transition from one sound to the next (from [j] to [a] in the word 'ja' for example), the boundary was placed where the vowel was 'pure'; where the influence of the preceding (or following) consonant was no longer present. This was done to ensure the most accurate measurements of the formants of the vowel. When it involved two vowels instead of a vowel and a consonant, the boundary was placed in the middle so that one vowel wouldn't be more influenced than the other.

When there was interference from another speaker or a sound, the word was marked, but the vowel was not, to avoid erroneous formant measurements. This occurred mostly in the 2009 recordings, where there was quite a lot of background noise during the recordings of participants 09M45, 09S43 and 09S45.

The singing of 45B has been annotated in the Words tier, but the vowel weren't indicated, because singing might give different formant values and thus influence the results in the wrong way.

2.2.2 Analysis by Praat script

A script was used to size down the recordings, making it possible to run the analysis faster (Appendix 3). It adjusts the sampling rate from 44100 Hz to 16000 Hz and converts the sound from stereo to mono.

Optimal formant analysis

A script was used to measure the formants with a range of formant ceilings from 4000 Hz to 6000 Hz at 20 Hz intervals (Appendix 7). This method was devised by Escudero et al. (2009). In an attempt to improve formant measurements and thus prevent the occurrence of many outliers, they determined F1 and F2 for all ceilings between 4000 and 6000 Hz in steps of 10 Hz (for male speakers). The ceiling that yields the lowest variation in all of the F1-F2 pairs was selected as the 'optimal ceiling'.

For the present study, the same method was chosen to measure the formants of each vowel for each speaker. The first three formants (F1, F2 and F3) were measured at three points of each vowel: 25%, 50% and 75%. This was done to facilitate measuring the formants of both monophthongs (at 50%) and diphthongs (at 25% and 75%). Intervals of 20 Hz were chosen and a ceiling range from 4000 to 6000 Hz; 100 ceiling values per occurring vowel. So for each vowel of each speaker the 3 formants were measured at 25%, 50% and 75% of the total length of the vowel, with a formant ceiling of 4000, 4020, 4040, etc. This yields a total of 900 formant measurements per speaker (100 ceilings x 3 formants x 3 measuring points). These results were all gathered in a table.

The variation within F1 and F2 was calculated for each of the results. The pair with the lowest variation was manually selected as the optimal formant. Then the data of speaker, vowel, F1, F2 and F2 were extracted into a new table, which was subsequently used to plot the results (per vowel, per group or as a whole). The procedure for the diphthongs was identical, but the 25% measurement points (F1a, F2a and F3a) and 75% measurement points (F1b, F2b and F3b) were extracted into separate tables, along with the information about speaker, vowel, ceiling and number of occurrences.

The optimal formant measurement turned out to give better results than the regular formant measurement, although the /i/ is still in the wrong place for 3 of 9 the speakers (09S45, 45B and 44P). There is an extra formant between the actual F1 and F2, which results in an F2 value that is much too low. The formant values in the original table (before the optimal ceiling was calculated) confirm this; the average F2 value for /i/ for speaker 09S45 is 1579 Hz. An examination of all the F2 values for /i/ for this speaker gave F2 values ranging from 373 Hz to 2253 Hz. The low F2 values are most likely caused by sounds in the recording that are not from human speech. The program doesn't distinguish between speech and other sounds, so it also measures formants for sounds that aren't speech. The same applies to the other two speakers with outlying /i/'s; the average F2 for /i/ for speaker 45B is 1322 Hz, the F2 ranges from 877 to 1934 Hz.

We tried four other ranges of formant ceilings before the 4000-6000 Hz range, but they were all less accurate (Table 4). That was calculated by performing a Discriminant analysis on the data: a method of classifying vowels that works in two steps. First, it uses the labels of a training set to train itself at assigning the vowels to the correct category. After the training it puts the vowels of the test set into categories, based on the information it has gathered during the training phase. The percentage of vowels that was put into the correct category (and thus has formant values that are typical for that category) can be calculated after that; these are the numbers that appear in Table 4.

The 4000-5200 Hz formant ceiling range was chosen based on the range mentioned by Escudero et al. (2009); 4000-6000 Hz. The upper limit was lowered to account for the fact that in the current investigation only male speakers participated, who generally have lower formants. In this range, 5 formants were measured. The results showed a lot of outliers, so some lower ranges were tried: 3000-4500 Hz, 2500-4000 Hz and 2000-3000 Hz. In the ranges 2000-3000 Hz and 2500-4000 Hz, 3 formants were measured. These ranges were chosen, because in the spectrum of the recordings there appeared to be no formants after 3000 Hz. The results of these ranges showed a lot of outliers and the usual triangular shape of the vowel space was mostly absent. This told us that the assumption that there were hardly any formants above 3000 Hz had to be wrong, so the final 4000-6000 Hz range was tried and this proved to give the best results.

Range (Hz)	Formants	Correctly classified vowels (%)		
		1944 group	2009 group	Total
4000-6000	6	86	76	73
4000-5200	5	80	70	62
3000-4500	4	78	69	63
2500-4000	3	72	63	54
2000-3000	3	65	61	52

Table 4: Percentages of correctly classified vowels in a Discriminant analysis of the results of the various optimal formant measurements.

Formant analysis

The first method that was used to analyse the data was a standard formant analysis. A script (Appendix 5) was used to analyze the individual vowels for each speaker. This script starts by listing the speakers. Subsequently a list of the monophthongs and diphthongs that were used in labelling is included in the script. Not all of them occur in each recording, some are only used by some of the speakers. The script then creates two tables: one table in which formants are to be stored and the other for the band filters. A procedure extracts the F0, F1, F2 and F3 for each vowel per speaker, as well as start and end time of each interval. This makes it possible to look up a specific vowel if anything were to seem wrong with it. Finally, the measurements are sent to the table and the table is saved. The analysis of the formants was done by saving the data in a Table, which was subsequently used to draw a scatter plot with F1 and F2 as criteria and the vowel labels as indicators. This results in an overview of all the tokens in a vowel space of F1 and F2, as in figure 2, where all tokens for [a], [i] and [u] are shown, which normally form the three corners of a vowel space, which is shaped like a triangle. In this picture it is more like a rectangle, because many tokens fall outside of the range where they should be.

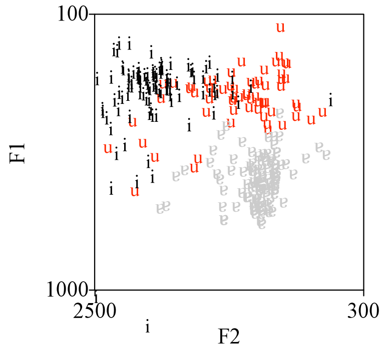

Figure 2: Tokens of [ɐ], [i] and [u] for all speakers, based on formant measurements.

We decided to select a different method of analysis because the results that the standard formant analysis yielded were not reliable (only 43% of the vowels were classified correctly in a Discriminant Analysis). This could be caused by the fact that the automated formant measurement doesn't account for background noise. This means that it will at times measure formants that aren't part of the speech. At other times it fails to measure formants, especially in the lower (F1) range. If the first formant is not recognized as such, the script would analyze the real F2 as F1, the real F3 as F2 etc. Because of this, a band filter analysis was done to eliminate the effect of the missing formants. This proved to be more reliable; 64.3% of the vowels were categorized correctly in the Discriminant Analysis.

Another change that was made after this analysis is the number of monophthongs and diphthongs that were used in labeling. As can be seen in the script (Appendix 5), the number of labels that were used in the standard formant analysis is 32; 22 monophthongs and 10 diphthongs. This was not representative of the groups, many labels were only used once and all of labels that were eventually removed represented allophones. They were adjusted in the TextGrids, by replacing them with one of the 15 monophthongs or 8 diphthongs from the final set (see script in Appendix 6 or 7 for the list).

Band filter analysis

The next method that was chosen is a band filter analysis. This is a software method that processes the sound wave into a set of decibel values. In this case, it was a set of 18 values in dB, which form the output of 18 band filters. The first step in this process is a Fast Fourier Transform (FFT), which decomposes the sound wave into the separate sines and cosines of which the sound signal is comprised. Then the energy of these signals is passed through Bark filters (mathematic formulas in this case) which produce values in dB.

The band filter analysis was carried out by adapting the Praatscript to have it measure both the formants and the band filter (Appendix 7). Subsequently, a Principal Component Analysis (PCA) and a Discriminant analysis were carried out on these results. The PCA is a method that computes the main contributors to the variance in the data without taking the labels into account. These factors that contribute most to the variance are called the Principal Components. They are computed by taking pieces of the sound wave and applying an FFT. The PCA then calculates the 18 factors that contribute most to the variance (in order of importance) from this large set of factors. It effectively reduces the dimensionality of the data, which makes it more manageable in analysis. Apart from that, it makes the composition of the signal visible.

The data that was used by the PCA hasn't been normalized for the different numbers of vowels per speaker, so it is biased in favour of the speakers with the most occurrences of the vowels. This is also true for the standard deviation (SD), which was calculated for some of the results. The SD is calculated by taking the mean of all values in a set of data (the formant values of F2 for [ɑ] for example, see §3.1). This mean is then subtracted from each value, giving the deviation from the mean for each value. Those numbers are then squared, the mean is calculated and finally the square root of that mean is the standard deviation. If one speaker has much more tokens for the vowel, it will weigh more heavily in the calculations, making the SD biased towards this speaker.

3. Results

In this chapter the results of the analyses will be discussed. First, the monophthongs will be analysed in general, followed by an overview of the results for each individual monophthong in §3.1.1. The same will be done for the diphthongs in §3.1.2.

3.1 General observations

From listening to the recordings it became apparent that the participants from the 1944 group sound different from the speakers of the 2009 group. It is audible that they are not from the same period in time. But what it is exactly that makes them sound different is not directly distinguishable. The only thing that stands out is the pronunciation of the /n/ at the end of verbs by the speakers 44B and 44T. This is generally omitted by modern day speakers in Amsterdam (and other parts of the Netherlands), but they occasionally do pronounce it. The fact that at other times they too omit it, may indicate that they only pronounce it because they are reading a text, where the /n/ is visible.

3.2 Monophthongs

From the labels of the vowels that were added to the TextGrids (§2.2.1), the following inventory of 15 monophthongs was made:

IPA	Speakers 2009					2009 total	Speakers 1944				1944 total	TOTAL
	09B36	09H32	09M45	09S43	09S45		44B	44P	44T	45B		
a	1	5	1	0	1	*8*	1	3	0	1	*5*	**13**
ɐ	7	13	13	10	9	*52*	12	18	9	15	*54*	**106**
ɑ	9	30	12	9	17	*77*	19	19	21	27	*86*	**163**
æ	3	3	3	6	7	*22*	1	2	0	7	*10*	**32**
ɛ	9	29	19	9	16	*82*	34	32	27	11	*104*	**186**
ə	29	71	32	28	37	*197*	71	77	76	68	*292*	**489**
i	8	15	11	9	7	*50*	11	22	15	7	*55*	**105**
ɪ	10	31	14	12	10	*77*	27	29	23	31	*110*	**187**
o	2	1	0	1	1	*5*	3	0	3	0	*6*	**11**
ɔ	11	16	14	11	12	*64*	22	13	18	14	*67*	**131**
u	3	10	3	3	4	*23*	7	10	11	12	*40*	**63**
y	6	8	5	5	7	*31*	4	2	4	6	*16*	**47**
ʏ	3	6	5	3	4	*21*	4	2	9	5	*20*	**41**
ø	0	4	4	5	6	*19*	3	6	2	3	*14*	**33**
œ	1	6	0	0	1	*8*	1	1	0	2	*4*	**12**
tot.	**102**	**248**	**136**	**111**	**139**	***736***	**220**	**236**	**218**	**209**	***883***	**1619**

Table 5: Number of tokens (labels in TextGrids) for each

The numbers in Table 5 don't reveal many differences between the two groups, especially when the different numbers of tokens are taken into account. The old group has between 241 and 281 vowels, the new group is divided: 09H32 has 302 vowels, the other four have between 133 and 167 (see Appendix 2 for exact numbers). So in general, the new speakers (with the exception of 09H32) have about half as much vowels as the old group. (And 09H32 has about the same amount.) Based on labeling, no difference was found between the new and the old group regarding the pronunciation of monophthongs. Examination of the vowel spaces that were plotted with the results of the formant ceiling range from 4000 Hz to 6000 Hz reveals that there is no great difference between the new and the old group with regard to the location of the vowels in the vowel space. The vowels of the new group cover a slightly larger area of the vowel space than those of the old group (Figure 3).

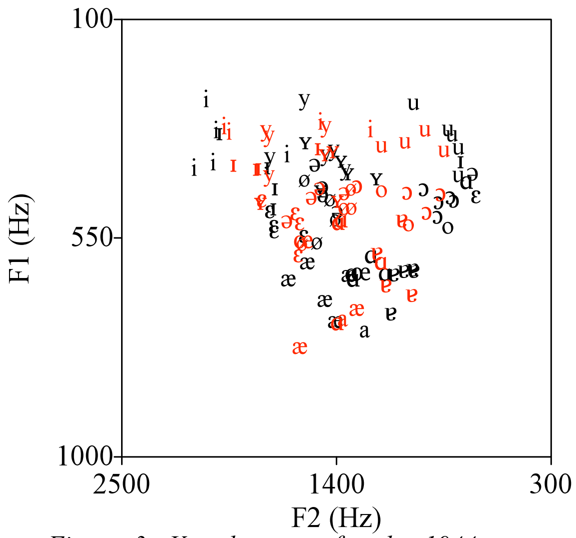

Figure 3: Vowel spaces for the 1944 group (grey) and the 2009 group (black), from optimal ceiling formant analysis.

The schwa will not be discussed, because virtually any unstressed vowel can be pronounced as such in the Dutch language and judging by the numbers in Table 5 this is the case for Jordanese as well.

/aa/ ('laat')

The long vowel /aa/ is mentioned in the study by van Lennep & Alberdingk Thijm (1877) as being pronounced either as 'ao' or as 'ae'. In Clason (2009) this is suspected to be a gender specific divergence. It has only one male speaker, but the results of the present study are congruent with the results that were found there; the one male speaker from Clason (2009) pronounced /a:/ as [ɐ], while the two female participants had a nasalized [ã]. The male speakers from the present study all say [ɐ]. This is also the pronunciation that is mentioned in the other previous studies; an [ɔ]-like pronunciation of [a:]. The notation for the sound differs between the publications; some note it as 'ao' (van Lennep & Alberdingk Thijm 1877), others as 'oa' (Schatz 1987). In this study the IPA symbol 'ɐ' was chosen to facilitate labeling if the TextGrids.

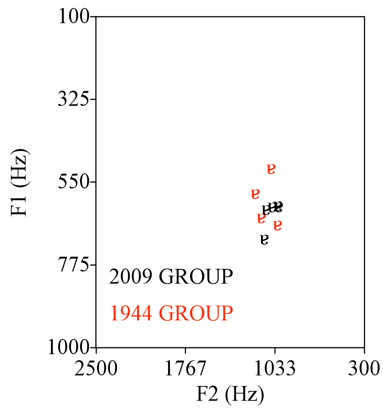

Figure 4: Tokens for /aa/ for the 2009 group (black) and the 44-45 group (grey) from optimal ceiling formant analysis.

The recordings of the female speakers that were made at the start of this investigation (see §2.1.1) were examined to see what kind of /aa/ they produce. By selecting the vowel and listening to it, we concluded that at least two of the three female speakers pronounce /aa/ as a nasalized vowel: [ã]. The third speaker uses both the nasalized and the [ɔ]-like variants of /aa/. These findings seem to support the findings of Schatz (1987) that female speakers of the dialect of Amsterdam pronounce /aa/ as the nasalized vowel [ã].

[ɑ] ('lat')

Both Winkler (1874) and Schatz (1987) report that the /ɑ/ is palatalized when followed by a /d/, /t/ or /n/. Schatz also adds /s/ to this list. The /d/ that Winkler mentioned sounds like [t] as a result of a Dutch pronunciation rule; when the /d/ is at the end of the syllable, it is pronounced as [t]. Since the context of the vowels hasn't been involved in the current investigation, this can't be investigated right now. A search of the TextGrids using the 'Find' function (with the search term '\as', to search for the IPA labels of [ɑ]) revealed that there are between 2 and 11 words per speaker that meet the requirements. These requirements are that they are words that have an [ɑ] in a syllable that ends in [t], [n] or [s] (from here on called 'palatalized tokens'). The total of tokens for [ɑ] per speaker compared to the number of palatalized tokens (Table 5) reveals that in most cases, about a third of the tokens is followed by [n], [s] or [t]. If the phenomenon is present, a third of the vowels should be palatalized and thus have a higher F2 than the other tokens.

	09B36	09H32	09M45	09S43	09S45
[ɑ] ('NORMAL' TOKENS)	9	30	12	9	17
[ɑ̣] (PALATALIZED TOKENS)	2	10	4	2	3
MEAN F2 NORMAL [ɑ]	1111	1268	1404	1120	1275
MEAN F2 PALATALIZED [ɑ̣]	1036	1441	1396	1287	1495
MEAN F2 NORMAL [ɛ] + SD	1152	1399	1586	1292	1470
SD ALL TOKENS [ɛ]	41	131	182	172	195
	44B	44P	44T	45B	
[ɑ] ('NORMAL' TOKENS)	19	19	21	27	
[ɑ̣] (PALATALIZED TOKENS)	6	7	9	6	
MEAN F2 NORMAL [ɑ]	1157	1441	1373	1396	
MEAN F2 PALATALIZED [ɑ̣]	1291	1493	1437	1561	
MEAN F2 NORMAL [ɑ] + SD	1211	1631	1493	1634	
SD ALL TOKENS [ɑ]	54	190	120	238	

Table 6: Values of F2 and SD for the palatalized tokens of [ɑ] and the other tokens of [ɑ].

The vowels (and measurements) from the words that comply with the requirements were abstracted from the table of formant measurements. The mean F2 and standard deviation (SD) for the normal tokens of [ɑ] per speaker was calculated and then that for the palatalized tokens (see Table 6). The mean F2's for the palatalized tokens are higher than

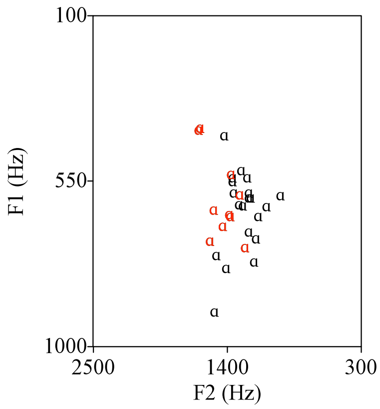

Figure 5: Total tokens for [a] in grey and palatalized tokens for [a] (with 2 σ ellipse) in black, taken from speaker 09H32.

those for the total of tokens for all speakers except 09B36 and 09M45, but they are still within one SD of the mean F2's for the normal tokens. Based on these numbers, the occurrence of palatalization of [ɑ] followed by [n], [s] or [t] has not been confirmed.

The total of tokens for [ɑ] and the palatalized tokens were abstracted from the table for speaker 09H32, the participant with the greatest number of tokens, both in total and for the palatalized tokens. They were plotted into a vowel space (F1 vs. F2, figure 5) which shows that the palatalized tokens lie to the left of the area, indicating they generally have higher F2's than the normal tokens. There are some normal tokens in the same area as the palatalized tokens; it could be that the vowel tokens from that area are all palatalized, even if they are not followed by [n], [s] or [t]. The other possibility is that there is no palatalization, which would most likely given that the numbers in Table 3 don't support the presence of palatalized tokens of [ɑ]. However, while searching for palatalized tokens for the short /e/ (see below), a number of [ɛ]-labels were encountered with words that have a short /a/ in the spelling. The fact that these words with an /a/ in the spelling were labelled with [ɛ] indicates that there might be palatalization involved in these cases. The words were 'wat' (occurred 6 times) and 'kan' (3 occurrences) and have an average F2 of 1724 Hz, which is consistent with the F2 values of [ɛ] (see Table 7) and significantly higher than the F2's for [ɑ].

[e] ('leg')

	09B36	09H32	09M45	09S43	09S45
[ɛ] (NORMAL TOKENS)	9	29	19	9	16
[ɛ] (PALATALIZED TOKENS)	2	5	6	2	3
MEAN F2 NORMAL [ɛ]	1792	1707	1721	1571	1727
MEAN F2 PALATALIZED [ɛ]	2115	1936	1858	1684	1817
MEAN F2 NORMAL [ɛ] + SD	2442	1922	1871	1720	1923
SD ALL TOKENS [ɛ]	650	215	150	149	196
	44B	44P	44T	45B	
[ɛ] (NORMAL TOKENS)	34	32	27	11	
[ɛ] (PALATALIZED TOKENS)	10	5	2	0	
MEAN F2 NORMAL [ɛ]	1599	1786	1619	1701	
MEAN F2 PALATALIZED [ɛ]	1723	1859	1742	0	
MEAN F2 NORMAL [ɛ] + SD	1768	1905	1740	1966	
SD ALL TOKENS [ɛ]	169	119	121	265	

Table 7: Values for the palatalized tokens of [ɛ] and the other tokens of [ɛ].

Schatz reports that the short /ɛ/ is also palatalized, just as the /ɑ/ is. The palatalization takes place under the same circumstances. The other studies don't mention the pronunciation of this vowel. The tokens were examined in the same way as the tokens for [ɑ]; the palatalized tokens were extracted from the table of the formant analysis after selecting them from the TextGrids, after which the mean F2's for the total and the palatalized tokens was calculated for each speaker. All of the mean F2's for the palatalized tokens are higher than the mean F2's for the total of tokens, but they are still within one standard deviation of them. This means that the palatalization isn't statistically proven. The tokens of speaker 44B were plotted to illustrate this, because this is the participant that has the greatest number of tokens in total and the most palatalized tokens (Figure 6). As was the case with the palatalized tokens for [ɑ], the palatalized tokens for [ɛ] are in the upper range of F2's, but the area also contains some tokens that are not palatalized tokens. This may mean that other contexts also lead to palatalization, or that there is no real palatalization.

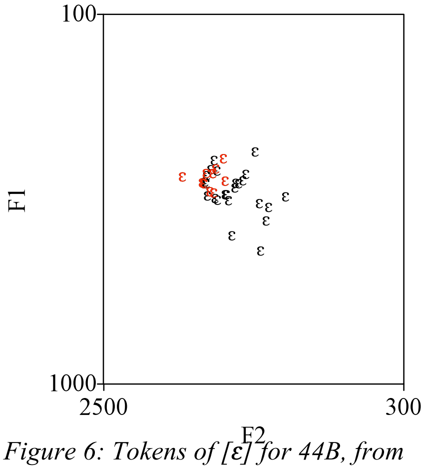

Figure 6: Tokens of [ɛ] for 44B, from formant analysis. Palatalized tokens in red, others in black.

Apart from the palatalized tokens, a few [ɛ]- tokens were found that were labelled with words that have a short /a/, so they provide proof for the palatalization of [ɑ] in these contexts (see section /a/ above for more details). There were also some cases of /e/ being labelled with [ɪ]: 'met', 'declaratie' (44P) and 'denk' (45B), for example. This may indicate that there is some palatalization, in spite of the numbers that contradict it. The ensuing consonants aren't always those mentioned by Schatz, it also occurs with [k] and [ŋ].

[i] ('liep')

Lennep & Alberdingk Thijm (1877) reported that the long /ie/ is diphthongized in words ending in [n] or [l]. A search of the TextGrids revealed that this pronunciation is still present in all speakers from the old group (in words like 'tien' and 'zien' for example), yet it is not present in any of the speakers from the group of 2009. The difference between the two groups of speakers has been observed both by listening to the recordings and by examining the TextGrids and is considered to be reliable.

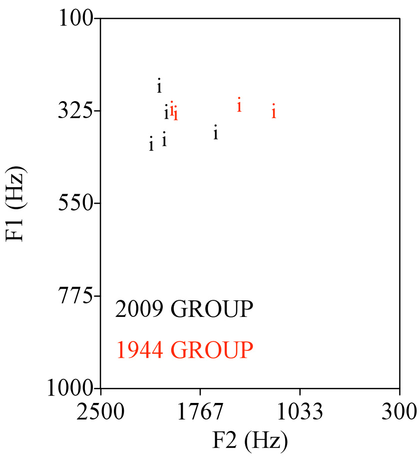

Figure 7: Optimal formant measurement results for [i] for the 2009 and 1944 participants.

With regard to the pronunciation of the [i] in general, it is difficult to determine whether there is a difference between the groups at the hand of optimal formant analysis, because of the many outliers in this vowel category. The optimal formant measurement resulted in six tokens that are most likely correct, but the other three tokens are obvious outliers (Figure 7). The PCA analysis of the band filter measurements will be used to analyse the vowel space of this vowel. It shows similar images for all speakers (Figure 8). Based on that, it is assumed that there are no differences between the groups regarding the pronunciation of [i] in general.

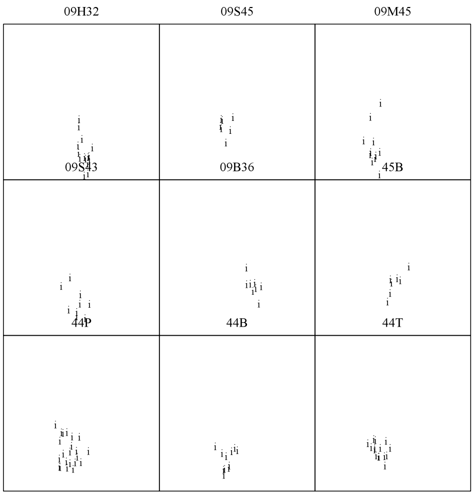

Figure 8: PCA configuration of the first 2 principal components of the tokens of [i] for each of the participants.

The x-axis represents the first principal component (pc1) and runs from -460 to -90 for each of the participants.

The y-axis represents the second principal component (pc2) and runs from -50 to 100 for each of the participants.

[ɪ] ('lip')

This vowel hasn't been specifically mentioned in any of the previous researches, which means that there is probably nothing about the Jordanese [ɪ] that makes it different from Standard Dutch. The optimal formant measurement showed too many outliers, so again we will use PCA. No differences between the two groups were found for [ɪ]; the configuration of the PCA analysis of the speakers has similar dispersions of the vowel for most of the speakers (Figure 9). Only speakers 09H32 and 09B36 have slightly different images; that of 09H32 is shifted downward and that of 09B36 is shifted to the left, compared to the other images.

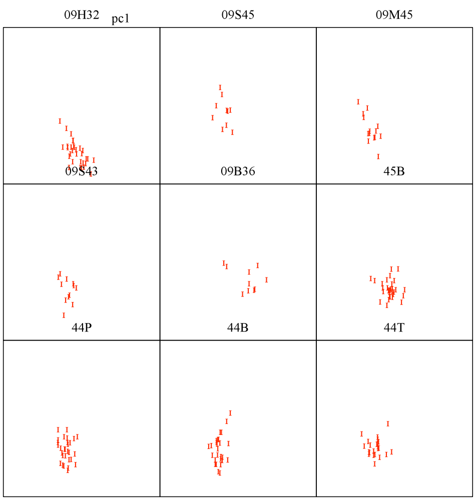

Figure 9: PCA configuration of the first 2 principal components of [ɪ] for each of the participants.

The x-axis represents the first principal component (pc1) and runs from -460 to -90 for each of the participants.

The y-axis represents the second principal component (pc2) and runs from -50 to 100 for each of the participants.

[o] ('boom')

Both of the previous researches that mention the long /oo/ (van Lennep & Alberdingk Thijm 1877 and Schatz 1987), report that it is often diphthongized. That is probably why so few tokens for the monophthong [o] were found. Only 5 out of 9 speakers use it, with a maximum of 3 occurrences in speaker 44B and 44T.

Because the optimal formant measurement disregards vowels that are only used once, this method will not be used for identifying differences between the groups; it leaves out the results for the speakers that only used [o] once (resulting in only 3 tokens instead of 6). The PCA isn't suitable either, because it doesn't handle vowels that occur only once very well. The original formant analysis shows that the tokens of the 2009 group all have lower F2's than those of the 1944 group (Figure 10). Whether it is a coincidence or regularity is impossible to determine due to the small set of tokens.

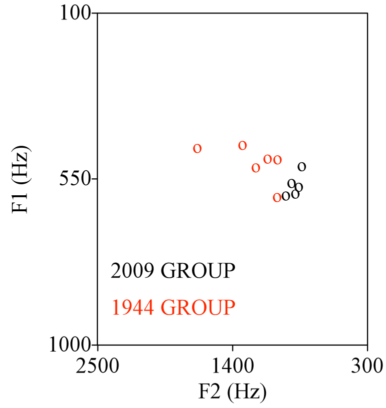

Figure 10: Tokens of [o] from normal formant measurement for all speakers.

[ɔ] ('bom')

The [ɔ] is not mentioned in any of the previous studies. The optimal formant measurement shows that there are no differences between the groups regarding the pronunciation of this vowel (Figure 11). There is one outlier with an unusually high F2, which is considered to be caused either by an error in the calculation of the formants (see §2.2.2, Band filter analysis) or it could coincidently have been the vowel with the lowest variance in spite of the high F2.

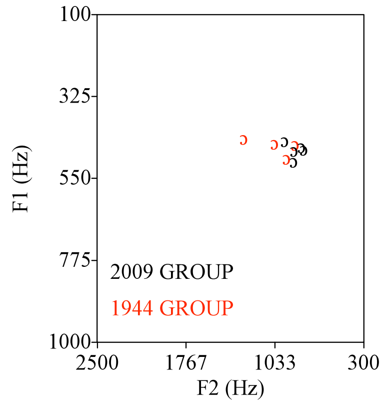

Figure 11: Tokens of [ɔ] for both groups, from optimal formant analysis

[u] ('boek')

This vowel isn't mentioned either in the earlier studies. Plotting the results of the optimal formant measurement (Figure 12) reveals that the tokens of the new group generally have lower F2's, but whether this is significant isn't clear, because the tokens of the groups are still very close together. Only the upper two tokens of the old group fall outside of the cluster, so it might be that they just happen to have higher F2's coincidentally. The average F2 of the old group is 1000 Hz and that of the new group is 836 Hz. Both values seem a bit high, but they are consistent with the

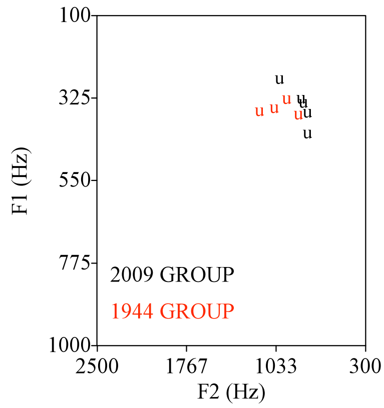

Figure 12: Tokens of [u] for both groups, from optimal formant analysis

values of [u] found in the normal formant analysis. For now however no significance will be attached to these results.

[y] ('buur')

For [y], the plot of the optimal formant measurement (Figure 13) reveals that there appears to be no difference in pronunciation between the groups. The tokens for both groups are in the same area; they have similar formant values and thus are pronounced in similar ways.

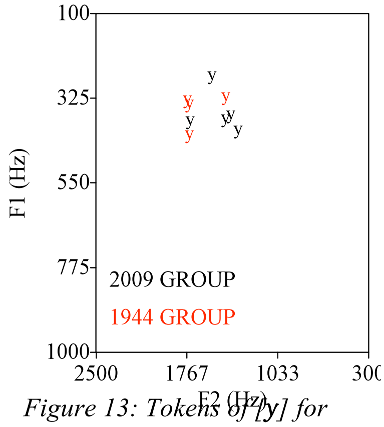

Figure 13: Tokens of [y] for both groups, from optimal formant analysis

[ʏ] ('put')

In the case of [ʏ], there is one outlier in the 1944 group. It has an F2 that is a bit higher than the other tokens (Figure 14). In general, there are no differences between the groups; the tokens all have similar formant values and are probably pronounced in identical ways.

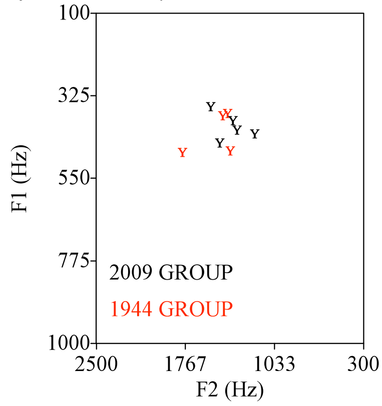

Figure 14: Tokens of [ʏ] for both groups, from optimal formant analysis

[ø] ('deuk')

The [ø] doesn't appear to be pronounced differently between the groups. It does have two (or more) pronunciations within some of the speakers. In §3.1.2 the pronunciation of /eu/ as a diphthong will be discussed. This is much less common than the monophthong however. The plot of the tokens of [ø] makes clear that there is no obvious difference between the groups in the pronunciation of [ø] (Figure 15).

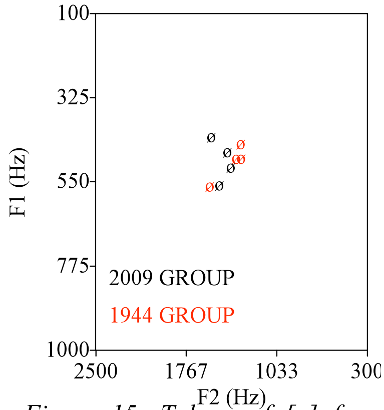

Figure 15: Tokens of [ø] for both groups, from optimal formant analysis

[œ] ('huis')

There is only one speaker who uses this pronunciation for /ui/ regularly; 09H32. He uses it 6 times, and the diphthong [œy] only once. The other speakers use the diphthong more than the monophthong or approximately equally (see Table 8). The optimal formant measurements of [œ] for 09H32 demonstrate that it is in the same area as the 25% measuring points for the diphthong [œy]; 09H32 has an F1 of 620 Hz and an F2 of 1273 Hz, the average for the 25% point F1's is 673 Hz and the average F2 is 1176 Hz. The only other speaker who used the [œ] more than [œy] is 45B, but he only uses it twice. His mean F2 (1566 Hz) is a bit higher than that of 09H32 (1273 Hz), but given the small number of tokens, there is no way to tell if this is a regularity or a coincidence.

IPA	09B36	09H32	09M45	09S43	09S45
œy	2	1	2	3	2
œ	1	6	0	0	1
IPA	44B	44P	44T	45B	
œy	3	0	0	1	
œ	1	1	0	2	

Table 8: Number of tokens per speaker for both allophones for /ui/: [œy] and [œ].

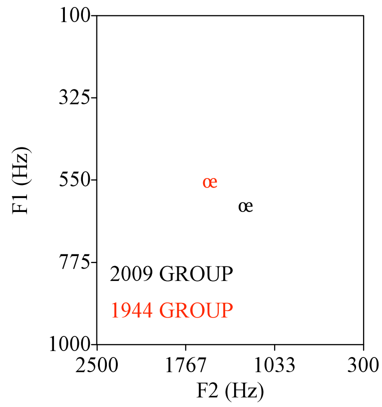

Figure 16: Tokens of [œ] for both groups, from optimal formant analysis

3.3 Diphthongs

The labelling of the diphthongs resulted in the following distribution of the individual diphthongs for each of the speakers:

IPA	STANDARD DUTCH	09B36	09H32	09M45	09S43	09S45	44B	44P	44T	45B
au	/au/	7	9	6	0	8	0	0	0	6
ɑu	/au/	0	0	1	6	0	7	4	4	1
æi	/ij/	1	1	0	0	1	9	0	0	0
ɛi	/ij/	4	5	2	1	1	3	0	4	0
ei	/ee/	11	18	11	7	10	10	7	7	20
ou	/oo/	4	15	8	3	6	8	3	6	13
øy	/eu/	2	0	0	0	0	1	0	1	1
œy	/ui/	2	1	2	3	2	3	0	0	1

Table 9: Number of tokens for each diphthong per speaker

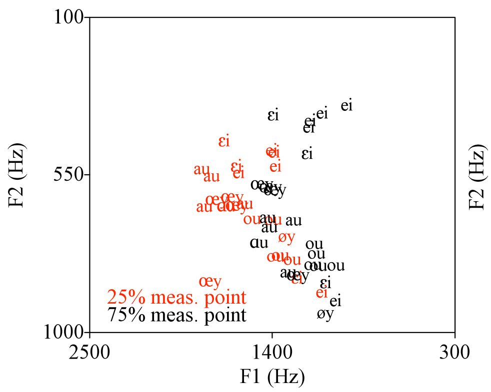

Figure 17: All tokens of the 2009 group for the 25% and 75% measuring points of the diphthongs for both groups, from optimal formant measurement

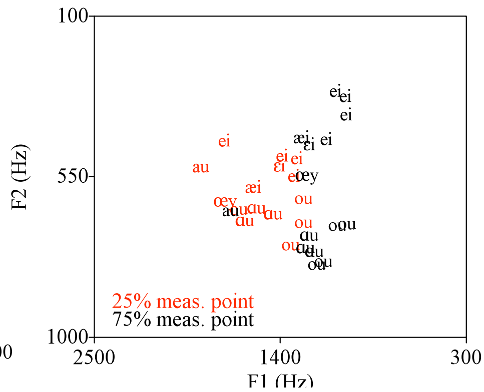

Figure 18: All tokens of the 1944 group for the 25% and 75% measuring points of the diphthongs for both groups, from optimal formant measurement

There are some differences between the two groups. The first is in the numbers for [au] and [ɑu], which show a difference in pronunciation for /au/ (or /ou/). The second is the pronunciation of /ij/ and /ei/, which is visible from this table in the numbers for [æi] and [ɛi], the two diphthongs that were used to transcribe the sound. The vowel spaces of the diphthongs in general (Figure 17 & 18) don't differ greatly between the two groups; the only visible difference is that vowel space of the 2009 group is a little bit larger than that of the 1944 group.

/ij/ and /ei/ ('lijd' and 'leid')

Another difference between the groups is the pronunciation of /ij/ (or /ei/, which has the same pronunciation). In total, five different pronunciations (allophones) were found for this vowel; the monophthongs [a], [æ] and [ɛ] and the diphthongs [ɛi] and [æi] (Table 10). All of the participants from 2009 have at least the pronunciations [æ] and [ɛi] (Table 9). In the old group all participants have [ɛ], 3 out of 4 have [ɛi], 2 out of 4 have [æ] and 1 has [æi]. There is also a fifth pronunciation found in the old group that is not present in the new group: [a]. This pronunciation is found with the same two speakers that have [æ]. Whether that is a coincidence or regularity cannot be ascertained from the current set of participants, it would need to be researched with a larger group of speakers. In the previous researches (§1.2) the [a] is always one of the pronunciations that are mentioned for /ij/ along with [ɛ]. The most recent reference to this is from 1992 (Berns), so if the absence of [a] as an allophone for /ij/ in the 2009 group is absolute, it would have to be a very recent development.

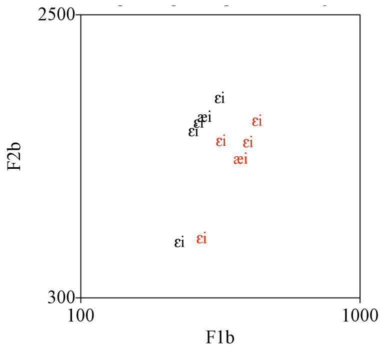

Figure 19: Diphthongs for /ij/ for all speakers, from optimal formant measurement

A pattern for selection of the allophones could not be found, it appears to be completely random; some speakers say [æ] in words ending in [n] and [ɛi] in word final position, others do it the other way around, etc.

SPEAKERS 2009	09B36	09H32	09M45	09S43	09S45
PRONUNCIATION	æ, æi, ɛi	æ, æi, ɛ, ɛi	æ, ɛ, ɛi	æ, ɛ, ɛi	æ, ɛ, ɛi
SPEAKERS 1944-45	44B	44P	44T	45B	
PRONUNCIATION	ɛ, ɛi, æi	a, æ, ɛ	ɛ, ɛi	a, æ, ɛ, ɛi	

Table 10: Pronunciations of /ij/(or /ei/) for all of the speakers

/au/ and /ou/ ('koud' and 'lauw')

There appears to be a difference between the old speakers and the new speakers regarding the pronunciation of /au/. Based on the labelling it was found that most of the new speakers say [au] (all except 09S43) and most of the old speakers say [ɑu] (all except 45B). This is supported by the formant analysis, which shows that the speakers that say [au] generally start at a higher F1 and F2 than the speakers that say [ɑu] (see Figure 20).

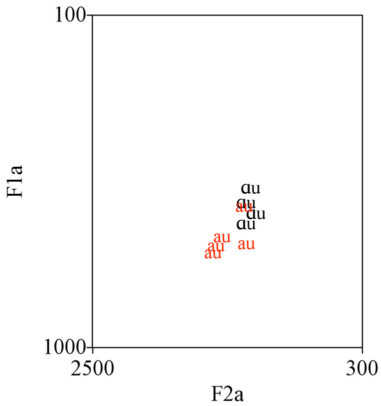

Figure 20: 25% points for [au] *and* [ɑu] *from optimal formant measurements for all speakers*

/ee/ ('leeg' and 'lege')

The long /ee/ is pronounced as a diphthong; both groups say [ei]. This is the only pronunciation found for this vowel. A difference between the groups is that the area that the diphthong covers in the vowel space appears to be much bigger for the 2009 group than it is for the 1944 group, but this is caused by one of the tokens that was measured wrong and has very low F2's (for both the 25% and 75% measuring points, see Figure 21). If this token is ignored, the distribution of the tokens is the same for both groups (Figure 21 & 22).

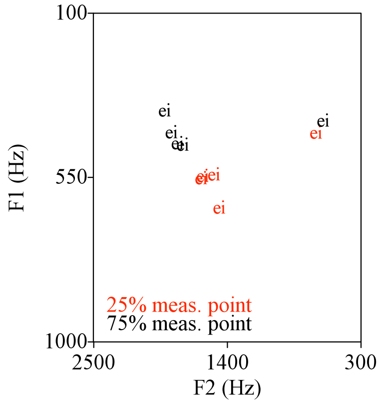

Figure 21: Tokens of [ei] for the 1944 group from optimal formant measurement.

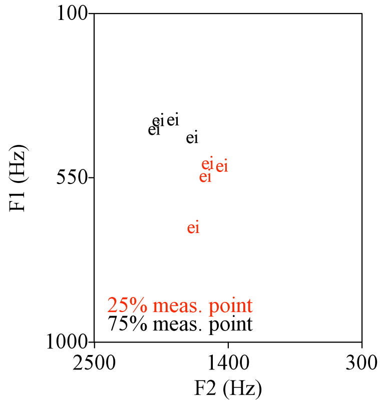

Figure 22: Tokens of [ei] for the 2009 group from optimal formant measurement.

/oo/ ('boom')

This sound is almost exclusively pronounced as [ou]. This was already reported by van Lennep and Alberdingk Thijm in 1877 and in every research since that time. It is still the predominant trend, although there are a few cases of the monophthong [o] (see §3.1.1). The pronunciation mentioned by Commandeur (in Berns 2002), is not congruent with the pronunciations mentioned in the rest of the previous investigations. He reports the long /o/ being pronounced as [ø], which doesn't occur in the results of the current investigation. There does not appear to be a difference in pronunciation between the groups; all tokens are in the same area (Figure 23&24).

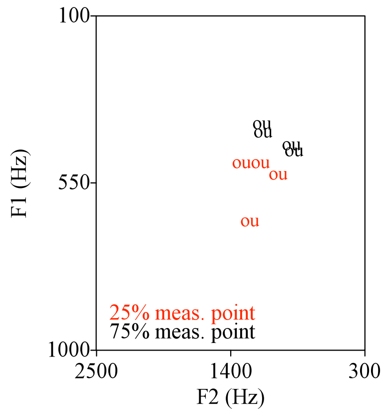

Figure 23: Tokens of [ou] for the 1944 group from optimal formant measurement.

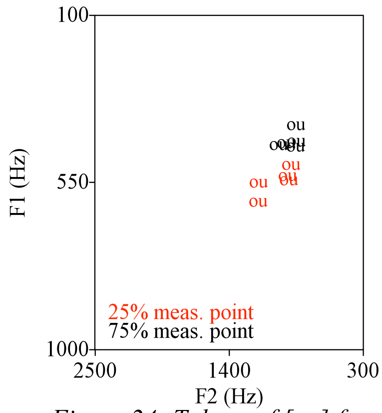

Figure 24: Tokens of [ou] for the 2009 group from optimal formant measurement.

/ui/ ('huis')

In the previous studies the pronunciation of /ui/ has been reported as [ɔi] by van Lennep & Alberdingk Thijm (1877) and as a monophthong by Schatz (1987). In Standard Dutch it is a diphthong. The participants pronounce it in a variety of ways (see Table 11 and Figure 24&25). The participants from the 2009 group all have [œy]. Three of them also have [œ], and one other has the monophthong [a] (which only occurs once). In the 1944 group only 44B has [œy] and the only other diphthong in that group is the [øy] of 44T. In general, all new speakers have a diphthong and a monophthong (except for 09S43), while two speakers from the old group exclusively have monophthongs. From this it could be deducted that in 1944 the diphthongal pronunciation of /ui/ was less common than it is in 2009. The pronunciation [ɔi] that van Lennep and Alberdingk Thijm reported in 1877 is present in neither of the groups.

SPEAKERS 2009	09B36	09H32	09M45	09S43	09S45
PRONUNCIATION	œ, œy	œ, œy	a, œy	œy	œ, œy
SPEAKERS 1944-45	44B	44P	44T	45B	
PRONUNCIATION	œ, œy	œ	øy	œ, ø, ʏ	

Table 11: Pronunciations of /ui/ for all of the speakers as labelled in the

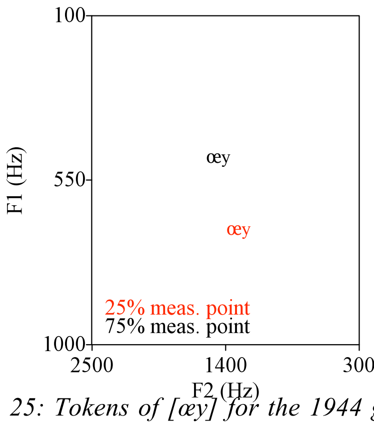

Figure 25: Tokens of [œy] for the 1944 group from optimal formant measurement

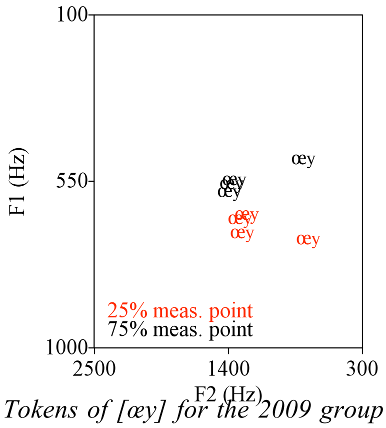

Figure 26: Tokens of [œy] for the 2009 group from optimal formant measurement

/eu/ ('deuk')

In Standard Dutch this vowel is pronounced as the monophthong [ø], but Schatz (1987) reported that it is often diphthongized. This is congruent with the results from the current investigation; it is pronounced both as [ø] and as [øy], but the monophthong is most common. Only one speaker exclusively uses a diphthong, and two speakers use both allophones. However, these results are questionable because the vowel is used very few times. The participants only have one, two or three tokens for it (see Table 12).

SPEAKERS 2009	09B36	09H32	09M45	09S43	09S45
PRONUNCIATION	øy	ø	ø	ø	ø
SPEAKERS 1944-45	44B	44P	44T	45B	
PRONUNCIATION	ø, øy	ø	ø	ø, øy	

Table 12: Pronunciations of /eu/ for all of the speakers as labelled in the

4. Conclusions

This chapter is aimed at providing insight into the way that the results are related to the research questions. An overview of the vowel inventories for the 2009 group and the 1944 group will be given, followed by a comparison between the two. Finally, the research questions will be answered at the hand of these data.

4.1 Vowel inventories

The vowel inventories in this section will be composed of the vowels that are most common for the group in question. For example, if there are multiple allophones for a vowel and one occurs significantly more often than the other, the allophone that occurs most often will be mapped and the other(s) will be disregarded.

Vowel inventory 2009

The vowel inventory of the participants from 2009 was gathered from the discussions of the individual vowels in § 3.1. The 'schwa' has been left out of the overview, because it is more of a repository category than a single vowel. In total there are 10 monophthongs (or 11 when the schwa is counted) and 5 diphthongs (Table 13). The /a/ and /e/ have two allophones: the normal pronunciation is [ɑ] or [ɛ] respectively, but there is also a palatalized version of both vowels that occurs in syllables that end in [n], [s] or [t]. /ij/ also has two allophones; a monophthong [æ] and a diphthong [ɛi]. On average, these are used about equally in both groups, although there is a difference within speakers. Some speakers use the monophthong more than the diphthong and vice versa.

Monophthongs					
Orthography	/aa/	/a/	/e/	/eu/	/ie/
IPA	ɐ	ɑ	ɛ	ø	i
Orthography	/i/	/o/	/oe/	/uu/	/u/
IPA	ɪ	ɔ	u	y	ʏ
Diphthongs					
Orthography	/au/	/ij/	/ee/	/oo/	/ui/
IPA	ɑu	ɛi	ei	ou	œy
Allophones					
Orthography	/a/	/e/	/ij/		
IPA	ɛ	ɪ	æ		

Table 13: Vowel inventory of the 2009 group

Vowel inventory 1944

The vowel inventory of the old group also consists of 10 monophthongs and 5 diphthongs (Table 14), but /a/, /e/, /ie/ and /ij/ all have two allophones. The short vowels /a/ and /e/ are palatalized when followed by [n], [s] or [t]. The pronunciation of /ie/ is usually a monophthong ([i]), but it is diphthongized to [iə] in words that end in /l/ or /n/ (van

Lennep & Alberdingk Thijm 1877). The pronunciation of /ij/ by the old group has as many as 4 allophones (for speaker 45B, see §3.1.2), but [ɛ] and [ɛi] are used most often by the speakers in general. However, the allophones differ considerably between speakers.

MONOPHTHONGS					
ORTHOGRAPHY	/aa/ or /a/	/a/	/e/	/eu/	/ie/ or /i/
IPA	ɐ	ɑ, ɑ̜	ɛ, ɛ̜	ø	i
ORTHOGRAPHY	/i/	/o/	/oe/	/uu/	/u/
IPA	ɪ	ɔ	u	y	ʏ
DIPHTHONGS					
ORTHOGRAPHY	/au/ or /ou/	/ij/ or /ei/	/ee/ or /e/	/oo/ or /o/	/ui/
IPA	ɑu	ɛi	ei	ou	œy
ALLOPHONES					
ORTHOGRAPHY	/a/	/e/	/eu/	/ie/	/ij/ or /ei/
IPA	ɛ	ɪ	øy	iə	ɛ

Table 14: Vowel inventory of the 1944 group.

Comparison

When comparing the overviews of the vowel inventories it becomes evident that above all, there are a lot of similarities between the two groups (Table 15). This is not very surprising, because both groups essentially speak the same language and the time in between the recordings is about 65 years, which is not a very long time when it comes to language evolution. In those 65 years however, an important shift in population in the neighbourhood took place: in 1944 the neighbourhood was a rather secluded working class neighbourhood and nowadays it has a mixed population of upper class and lower class inhabitants.

	2009 GROUP	1944 GROUP
/aa/	ɐ	ɐ
/a/	ɑ, ɑ̜	ɑ, ɑ̜
/au/	**au**	**ɑu**
/e/	ɛ, ɛ̜	ɛ, ɛ̜
/ee/	ei	ei
/eu/	**ø**	**ø, øy**
/ie/	**i**	**i, iə**
/i/	ɪ	ɪ
/oo/	ou	ou
/o/	ɔ	ɔ
/oe/	u	u
/uu/	y	y
/u/	ʏ	ʏ
/ui/	œy	œy
/ij/	**æ, ɛi**	**ɛ, ɛi**

Table 15: vowel inventories for both groups with the differences in bold print.

The pronunciation of /au/ (or /ou/) appears to be different for both groups; the 2009 group predominantly says [au], the 1944 group mainly says [ɑu]. In each group there is one speaker present that uses the other allophone more than that which is common for his group (speakers 09S43 and 45B).

The 1944 group has two allophones for [i]; there is the monophthong [i] and the diphthongized [iə] when it is followed by [l] or [n]. This is not the case for the 2009 group, they only have the monophthong [i].

The pronunciation of /ij/ differs greatly between the groups and the speakers and even within a speaker. Many speakers (all except 44P) use both monophthongs and diphthongs. The diphthong is mostly [ɛi], but the monophthongal allophone that is used most often, is different for both groups. Both of the allophones in question are present in either group, but the participants of the 2009 group mostly say [æ], while the 1944 group used [ɛ] more often.

The 1944 group uses two allophones for /ui/ in equal amounts; œ, œy. Speaker 44T is an exception, he pronounces it as øy. The 2009 group uses œy most, only speaker 09H32 uses œ more than the diphthong.

Research question 1: Has the vowel inventory changed?

The 2009 group has less allophones than the 1944 group, which is cause for two of the four differences between the groups, regarding the pronunciations of /eu/ and /ie/. The other two differences are caused by shifts in the pronunciation of /au/ and /ij/. The vowel inventories have not changed in the sense that any vowels were added or deleted, but the pronunciation of several vowels has changed.

4.2 Vowel spaces

Vowel space 1944 group

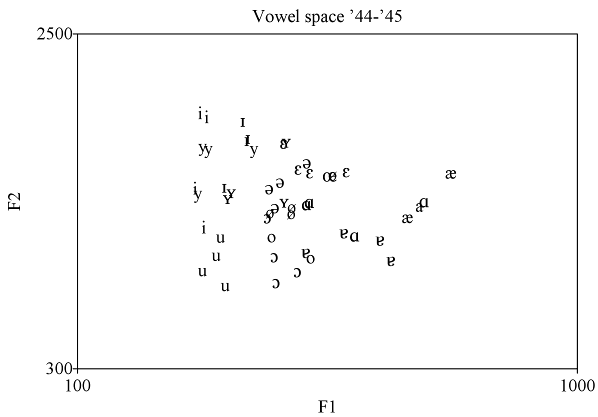

Figure 27: Monophthongs of 1944 group, from optimal formant measurement

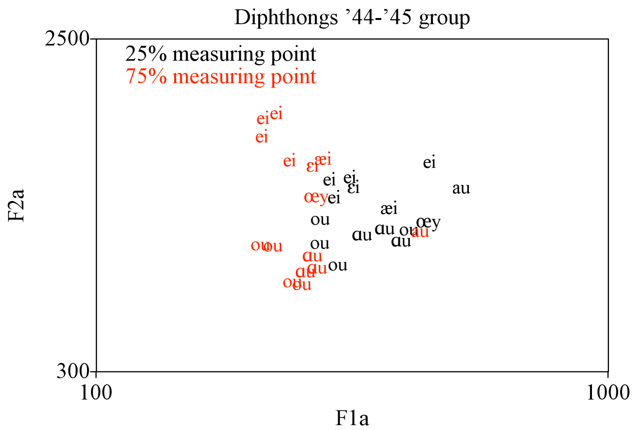

Figure 28: Diphthongs of 1944 group, from optimal formant measurement

Vowel space 2009 group

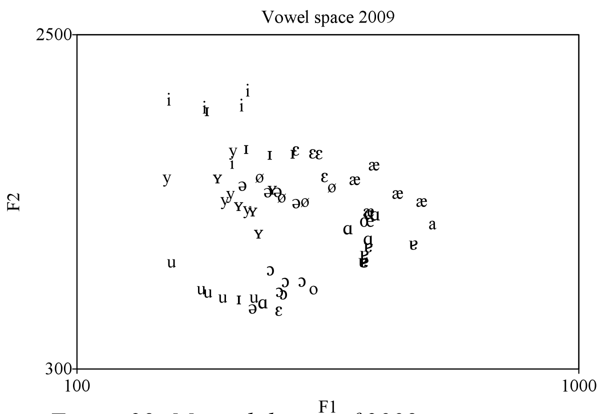

Figure 29: Monophthongs of 2009 group, from optimal formant measurement

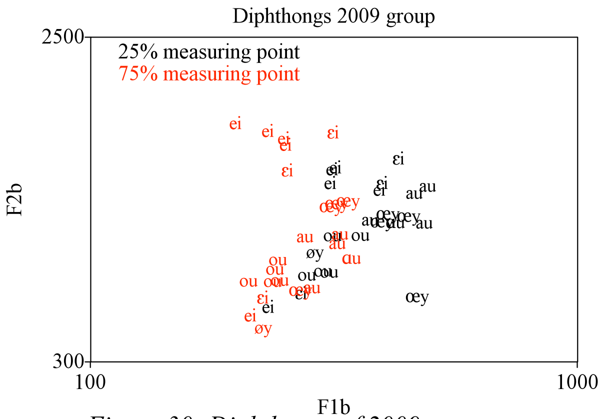

Figure 30: Diphthongs of 2009 group, from optimal formant measurement

Comparison between the vowel spaces

The vowel space of the 1944 group is a bit smaller that that of the 2009 group, both for the monophthongs and the diphthongs. This may imply that pronunciation in general has become a little bit more enunciated since that time. It is the reason for the fact that the tokens of [u] have lower F2's in the 2009 group than they do in the 1944 group. The same is true for the lower F2 values of [o] for the 2009 group. The other detectable difference is that the diphthong /au/ starts at a higher F2 for the 2009 group, confirming that they pronounce it differently from the 1944 group.

Apart from these three remarks, there are no significant differences between the vowel spaces of the two groups.

Research question 2: Has the vowel quality changed; do they have different formant values?

For some vowels, the vowel quality appears to have shifted. This involves the same vowels that were found to have changed in pronunciation, which seems to confirm that their pronunciation has changed.

Answer general research question

The pronunciation of the vowels of Jordanese has changed in a few cases since 1944. The articulation in general is a little more pronounced, the diphthong /au/ is different and a few of the allophones have disappeared. Apart from that the pronunciation has remained unchanged.

Most of the pronunciations that were described in the previous studies were confirmed by the present investigation, although some of them occurred only a few times and were therefore not included in the conclusions. The findings of previous studies that were not repeated in the current investigation are the pronunciation of /ui/ as [ɔi] (Winkler 1874) and the pronunciation of /oo/ as [ø] (Commandeur, in Berns 2002).

5. DISCUSSION

The poor quality of the recordings has led to many difficulties in the analysis of the vowels. The initial formant measurements were inaccurate because the standard formant frequency analysis can’t handle the background noise. It either measured formants that weren’t part of the speech or failed to recognize formants that *were* part of the speech. The band filter analysis that was subsequently carried out on the vowels gave some better results, but made it difficult to examine the differences, especially in the case of the diphthongs. Finally the formant ceiling analysis was carried out on the data and this proved to be the most reliable method of analysis, although in the case of [i] and [ɪ], the band filter analysis needed to be used as a supplementary method because of the aforementioned shortcomings of the formant measurements.

This has made clear how important it is to have ‘clean’ recordings, where no background noise is present, when using an automated method of analysis. The only method that would have been more reliable than those that have been used would have been to measure the formants by hand. This was not an option in the current investigation due to the short time span in which it was supposed to be carried out in combination with the relatively large number of tokens.

Another flaw in the design of this investigation has been the labeling of the TextGrids. They were labelled as accurately as possible. In hindsight it would have been useful to have phoneme labels as well, to be able make a distinction between the tokens of [ɛ] that were used for /e/ from those that were used for /ij/, to name just one example.

One of the matters that may be of interest for future research is the possible gender specific pronunciation of /aa/ as mentioned by Schatz (1987). It was not contradicted by Clason (2009) or the present investigation, but it might be interesting to conduct an investigation aimed at confirming Schatz’ statement.

Another subject of interest is the palatalization of /a/ and /e/ in syllables ending in [n], [s] or [t]. It was mentioned by Winkler (1874) and Schatz (1987), but it has not been confirmed by the current investigation. It might still be present in the modern Jordanese, but an investigation focused on this phenomenon would be needed to shed more light on this.

The pronunciation of the long vowels /aa/, /ee/ and /oo/ could also be investigated further. For each, both the Standard Dutch and the Jordanese form are used by the participants in the current investigation. There may be a pattern involved in the choice between the two possible forms, which might be revealed by a sociolinguistic study, assuming that the choice has to do with social factors.

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APPENDIX 1: LIST OF WORDS AND SENTENCES FOR THE 2009 RECORDINGS

bak	boek	één
baak	de baai?	twee
bek	wij	drie
beek	wijl	vier
bik	mooi	vijf
piek	wui	zes
bok	wuil	zeven
pot	wou	acht
pook	meeuw	negen
buk	meeuwen	tien
buut	nieuw	elf
beuk	nu	twaalf

Zijn grootvader is zijn afgod.

Pas op, de losse pekdraad hangt niet loodrecht.

De schoolkinderen gaan morgen weer met de meester naar zee.

Ja, de meid melkt het schaap om vijf uur.

Zijn zoon heeft nu koorts, maar zijn dochter is weer gezond.

Zijn in dit huis tien deuren van beukenhout?

Een getrouwde vrouw moet kunnen naaien en kousen stoppen.

Buiten is het nu flink koud, er valt veel sneeuw.

Die nieuwe jas van je broer is te nauw.

Appendix 2: Details of participant recordings

Participant	Number of Words	Number of Vowels	Length of recording
09S45	152	167	65.59 s
09H32	272	302	173.56 s
09M45	146	167	95.16 s
09S43	115	133	73.64 s
09B36	120	134	60.79 s
45B	247	272	214.33 s
44P	205	252	127.96 s
44B	214	281	117.18 s
44T	217	241	215.03 s

APPENDIX 3: SCRIPT FOR RESIZING THE RECORDINGS

```
speaker1$ = "45B"
speaker2$ = "44P"
speaker3$ = "44B"
speaker4$ = "44T"
speaker5$ = "09H32"
speaker6$ = "09S45"
speaker7$ = "09M45"
speaker8$ = "09S43"
speaker9$ = "09B36"

for i to 9
  speaker$ = speaker'i'$
  s = Read from file... 'speaker$'.WAV
  sm = Convert to mono
  smf = Resample... 16000 50
  Write to WAV file... 'speaker$'_m16.wav
  select s
  plus sm
  plus smf
  Remove
endfor
```

Appendix 4: Script for formant analysis

```
speaker1$ = "09H32"
speaker2$ = "09S45"
speaker3$ = "09M45"
speaker4$ = "09S43"
speaker5$ = "09B36"
speaker6$ = "45B"
speaker7$ = "44P"
speaker8$ = "44B"
speaker9$ = "44T"
numberOfSpeakers = 9
#
monoph1$ = "i"
monoph2$ = "\ic"
monoph3$ = "\ef"
monoph4$ = "y"
monoph5$ = "\yc"
monoph6$ = "a\:f"
monoph7$ = "u"
monoph8$ = "\ct"
monoph9$ = "\as"
monoph10$ = "\as\+v"
monoph11$ = "\ae"
monoph12$ = "o"
monoph13$ = "\as\T^"
monoph14$ = "\at"
monoph15$ = "\e-"
monoph16$ = "\hs"
monoph17$ = "\u-"
monoph18$ = "\oe"
monoph19$ = "\o/"
monoph20$ = "\as\-v"
monoph21$ = "a\-v"
monoph22$ = "\a~"
numberOfMonoph = 22
```

```
diph1$ = "ei"
diph2$ = "\o/y"
diph3$ = "ou"
diph4$ = "\efi"
diph5$ = "\asu"
diph6$ = "\oey"
diph7$ = "\as\ic"
diph8$ = "\ef\ic"
diph9$ = "au"
diph10$ = "\aei"
numberOfDiph = 10

tab = Create Table with column names... table 1500  speaker vowel start end F0 F1 F2 F3
F1a F1b F2a F2b F3a F3b

row = 0
for i to 1
  speaker$ = speaker'i'$
  call doFile 'speaker$'
endfor
#
echo speaker'tab$'vowel'tab$'dur'tab$'F1'tab$'F2'tab$'F3'tab$'
...F1a'tab$'F1b'tab$'F2a'tab$'F2b'tab$'F3a'tab$'F3b
#
procedure doFile fileName$
  .s = Read from file... 'fileName$'_m16.WAV
  f0 = To Pitch... 0.0 75 600
  formantCeiling = 5000
  select .s
  .formant = To Formant (burg)... 0.001 5 formantCeiling 0.025 50
  .tg = Read from file... 'fileName$'.TextGrid
  select .tg
  numberOfIntervals = Get number of intervals... 1
  for interval to numberOfIntervals
    label$ = Get label of interval... 1 interval
    if label$ <> ""
      start = Get starting point... 1 interval
```

```
end = Get end point... 1 interval
duration = end - start
select .formant
f1 = Get value at time... 1 (start+end)/2 Hertz Linear
f2 = Get value at time... 2 (start+end)/2 Hertz Linear
f3 = Get value at time... 3 (start+end)/2 Hertz Linear
f1a = Get value at time... 1 start+(end-start)*0.25 Hertz Linear
f1b = Get value at time... 1 start+(end-start)*0.75 Hertz Linear
f2a = Get value at time... 2 start+(end-start)*0.25 Hertz Linear
f2b = Get value at time... 2 start+(end-start)*0.75 Hertz Linear
f3a = Get value at time... 3 start+(end-start)*0.25 Hertz Linear
f3b = Get value at time... 3 start+(end-start)*0.75 Hertz Linear
row = row +1
select .tg
.found = 0
for a from 1 to numberOfMonoph
 if label$ = monoph'a'$
  .found = 1
 endif
endfor
for b from 1 to numberOfDiph
 if label$ = diph'b'$
  .found =  1
 endif
endfor
if .found = 1
 select tab
 Set string value... row speaker ...
 Set string value... row vowel 'label$'
   Set numeric value... row start start
   Set numeric value... row end end
   Set numeric value... row F0 f0
   Set numeric value... row F1 f1
   Set numeric value... row F2 f2
   Set numeric value... row F3 f3
   Set numeric value... row F1a f1a
   Set numeric value... row F1b f1b
   Set numeric value... row F2a f2a
```

```
          Set numeric value... row F2b f2b
          Set numeric value... row F3a f3a
          Set numeric value... row F3b f3b
     else
       printline: Error 'speaker$' 'begin' 'end' 'label$'
     endif
   endif
 endfor

 select .s
 plus .formant
 plus .tg
 Remove
endproc
#
select tab
Write to text file... formantanalyse.Table
```

Appendix 5: Script for band filter analysis and formant analysis

```
form Formantanalyse
  positive Bovengrens_(Hz) 5000
  natural Aantal_formanten 5
endform
nof = 18
printline Aantal formanten: 'aantal_formanten', bovengrens: 'bovengrens' (Hz)
#
speaker1$ = "09H32"
speaker2$ = "09S45"
speaker3$ = "09M45"
speaker4$ = "09S43"
speaker5$ = "09B36"
speaker6$ = "45B"
speaker7$ = "44P"
speaker8$ = "44B"
speaker9$ = "44T"
numberOfSpeakers = 9
#
monoph1$ = "i"
monoph2$ = "\ic"
monoph3$ = "\ef"
monoph4$ = "y"
monoph5$ = "\yc"
monoph6$ = "u"
monoph7$ = "\ct"
monoph8$ = "\as"
monoph9$ = "\ae"
monoph10$ = "o"
monoph11$ = "\at"
monoph12$ = "\oe"
monoph13$ = "\o/"
monoph14$ = "\sw"
monoph15$ = "a"
numberOfMonoph = 15
```

```
diph1$ = "ei"
diph2$ = "\o/y"
diph3$ = "ou"
diph4$ = "\efi"
diph5$ = "\asu"
diph6$ = "\oey"
diph7$ = "au"
diph8$ = "\aei"
numberOfDiph = 8

labelsb$ = "speaker vowel start end F0"
for i to nof
  labelsb$ = labelsb$ + " " + "b'i'"
endfor
for i to nof
  labelsb$ = labelsb$ + " " + "ba'i'"
endfor
for i to nof
  labelsb$ = labelsb$ + " " + "bb'i'"
endfor

tabf = Create Table with column names... tableFormants 2000  speaker vowel start end F0
F1 F2 F3 F1a F1b F2a F2b F3a F3b
tabb = Create Table with column names... tableBark 2000 'labelsb$'

row = 0
for i to numberOfSpeakers
  speaker$ = speaker'i'$
  call doFile 'speaker$'
endfor

procedure doFile fileName$
  .s = Read from file... 'fileName$'_m16.WAV
  .p = To Pitch... 0.0 75 600
  select .s
  .formant = To Formant (burg)... 0.001 aantal_formanten bovengrens 0.025 50
  select .s
```

```
.bf = To BarkFilter... 0.025 0.001 1.0 1.0 20
.tg = Read from file... 'fileName$'.TextGrid
select .tg
numberOfIntervals = Get number of intervals... 1
for interval to numberOfIntervals
 select .tg
 label$ = Get label of interval... 1 interval
 if label$ <> ""
  .found = 0
  for a from 1 to numberOfMonoph
   if label$ = monoph'a'$
    .found = 1
   endif
  endfor

  for b from 1 to numberOfDiph
   if label$ = diph'b'$
    .found =  1
   endif
  endfor

  if .found = 1
   row = row +1
   start = Get starting point... 1 interval
   end = Get end point... 1 interval
   duration = end - start
   .t25 = start+(end-start)*0.25
   .t50 = (start+end)/2
   .t75 = start+(end-start)*0.75

   select .p
   .f0 = Get value at time... .t50 Hertz Linear

   select .formant
   .f1 = Get value at time... 1 .t50 Hertz Linear
   .f2 = Get value at time... 2 .t50 Hertz Linear
   .f3 = Get value at time... 3 .t50 Hertz Linear
   .f1a = Get value at time... 1 .t25 Hertz Linear
```

```
.f1b = Get value at time... 1 .t75 Hertz Linear
.f2a = Get value at time... 2 .t25 Hertz Linear
.f2b = Get value at time... 2 .t75 Hertz Linear
.f3a = Get value at time... 3 .t25 Hertz Linear
.f3b = Get value at time... 3 .t75 Hertz Linear


select tabf
  Set string value... row speaker 'speaker$'
  Set string value... row vowel 'label$'
  Set numeric value... row start start
  Set numeric value... row end end
  Set numeric value... row F0 .f0
  Set numeric value... row F1 .f1
  Set numeric value... row F2 .f2
  Set numeric value... row F3 .f3
  Set numeric value... row F1a .f1a
  Set numeric value... row F1b .f1b
  Set numeric value... row F2a .f2a
  Set numeric value... row F2b .f2b
  Set numeric value... row F3a .f3a
  Set numeric value... row F3b .f3b

select .bf
for .ib to nof
 .b'.ib' = Get value in cell... .t50 .ib
 .ba'.ib' = Get value in cell... .t25 .ib
 .bb'.ib' = Get value in cell... .t75 .ib
endfor

select tabb
  Set string value... row speaker 'speaker$'
  Set string value... row vowel 'label$'
  Set numeric value... row start start
  Set numeric value... row end end
  Set numeric value... row F0 .f0
for .ib to nof
  Set numeric value... row b'.ib' .b'.ib'
```

```
      Set numeric value... row ba'.ib' .ba'.ib'
      Set numeric value... row bb'.ib' .bb'.ib'
    endfor
   else
    printline: Error 'speaker$' 'begin' 'end' 'label$'
   endif
  endif
 endfor

 select .s
 plus .formant
 plus .tg
 plus .p
 plus .bf
 Remove

endproc
#

printline row='row'
select tabf
Extract rows where column (text)... vowel "is not equal to"
Write to text file... formantanalyse_'aantal_formanten'ALL.Table
select tabb
Extract rows where column (text)... vowel "is not equal to"
Write to text file... bfanalyseALL.Table
```

Appendix 6: Script for optimal formant measurement with a range of formant ceilings

```
form Formantanalyse
  positive Bovengrens_(Hz) 5000
  natural Aantal_formanten 5
endform
nof = 18
printline Aantal formanten: 'aantal_formanten', bovengrens: 'bovengrens' (Hz)
#
speaker1$ = "09H32"
speaker2$ = "09S45"
speaker3$ = "09M45"
speaker4$ = "09S43"
speaker5$ = "09B36"
speaker6$ = "45B"
speaker7$ = "44P"
speaker8$ = "44B"
speaker9$ = "44T"
numberOfSpeakers = 9
#
monoph1$ = "i"
monoph2$ = "\ic"
monoph3$ = "\ef"
monoph4$ = "y"
monoph5$ = "\yc"
monoph6$ = "u"
monoph7$ = "\ct"
monoph8$ = "\as"
monoph9$ = "\ae"
monoph10$ = "o"
monoph11$ = "\at"
monoph12$ = "\oe"
monoph13$ = "\o/"
monoph14$ = "\sw"
monoph15$ = "a"
```

```
numberOfMonoph = 15

diph1$ = "ei"
diph2$ = "\o/y"
diph3$ = "ou"
diph4$ = "\efi"
diph5$ = "\asu"
diph6$ = "\oey"
diph7$ = "au"
diph8$ = "\aei"
numberOfDiph = 8

onder = 4000
boven = 5200
stap = 20
nstap = floor((boven - onder)/stap)
row = 0

nrows = nstap * 2000
tabf = Create Table with column names... tableFormants nrows speaker vowel bovengrens
start end F1 F2 F3 F1a F1b F2a F2b F3a F3b

for i to numberOfSpeakers
  speaker$ = speaker'i'$
  bovengrens = onder
  for j to nstap
    call doFile 'speaker$'
    bovengrens += stap
  endfor
endfor

procedure doFile fileName$
  .s = Read from file... 'fileName$'_m16.wav
  select .s
  .formant = To Formant (burg)... 0.001 aantal_formanten bovengrens 0.025 50
  .tg = Read from file... 'fileName$'.TextGrid
  select .tg
  numberOfIntervals = Get number of intervals... 1
```

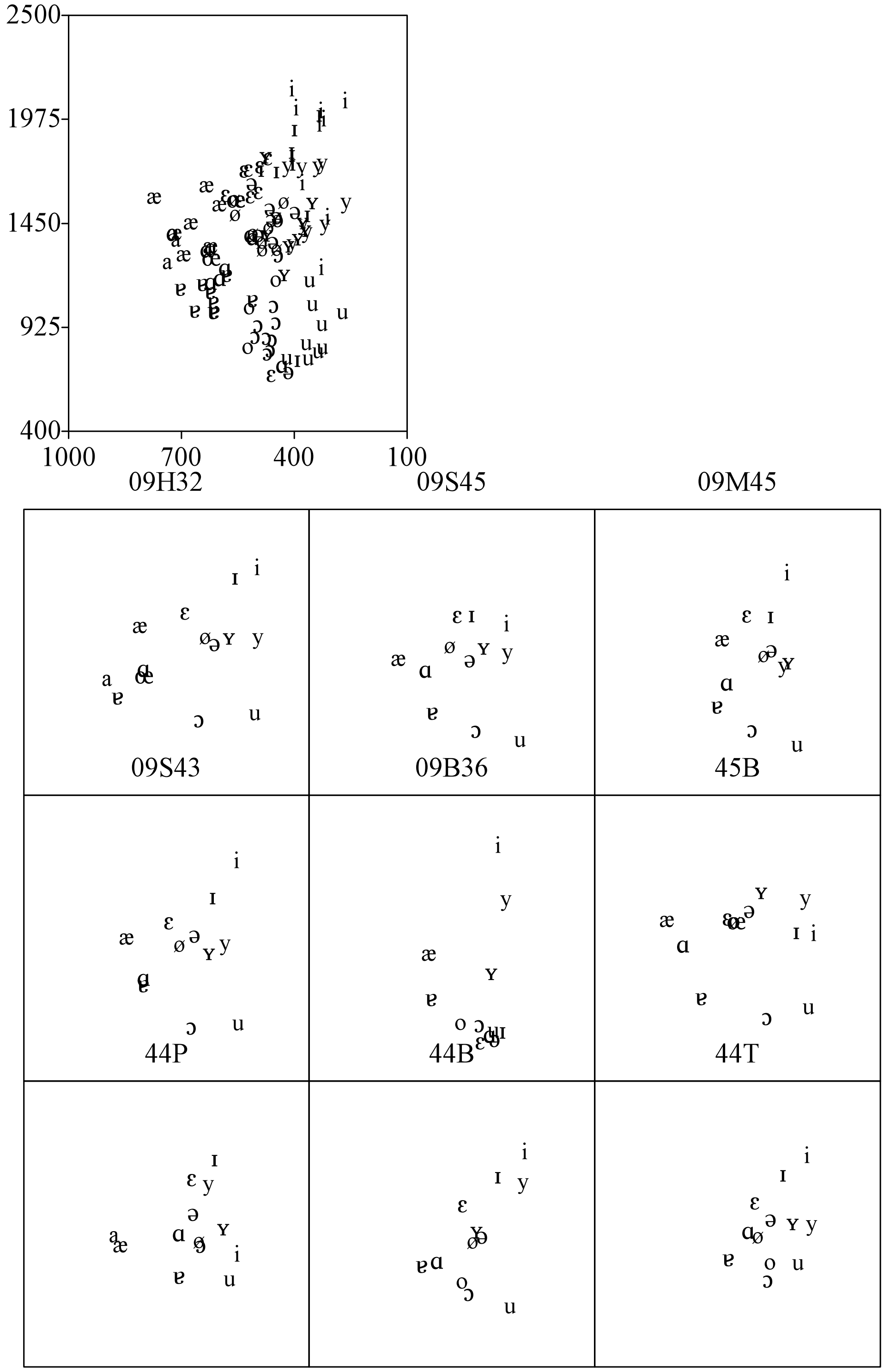
```
for interval to numberOfIntervals
 select .tg
 label$ = Get label of interval... 1 interval
 if label$ <> ""
  .found = 0
  for a from 1 to numberOfMonoph
   if label$ = monoph'a'$
    .found = 1
   endif
  endfor

  for b from 1 to numberOfDiph
   if label$ = diph'b'$
    .found =  1
   endif
  endfor

  if .found = 1
   row = row +1
   start = Get starting point... 1 interval
   end = Get end point... 1 interval
   duration = end - start
   .t25 = start+(end-start)*0.25
   .t50 = (start+end)/2
   .t75 = start+(end-start)*0.75

   select .formant
   .f1 = Get value at time... 1 .t50 Hertz Linear
   .f2 = Get value at time... 2 .t50 Hertz Linear
   .f3 = Get value at time... 3 .t50 Hertz Linear
   .f1a = Get value at time... 1 .t25 Hertz Linear
   .f1b = Get value at time... 1 .t75 Hertz Linear
   .f2a = Get value at time... 2 .t25 Hertz Linear
   .f2b = Get value at time... 2 .t75 Hertz Linear
   .f3a = Get value at time... 3 .t25 Hertz Linear
   .f3b = Get value at time... 3 .t75 Hertz Linear

   select tabf
```

```
          Set string value... row speaker 'speaker$'
          Set string value... row vowel 'label$'
          Set numeric value... row bovengrens bovengrens
          Set numeric value... row start start
          Set numeric value... row end end
          Set numeric value... row F1 .f1
          Set numeric value... row F2 .f2
          Set numeric value... row F3 .f3
          Set numeric value... row F1a .f1a
          Set numeric value... row F1b .f1b
          Set numeric value... row F2a .f2a
          Set numeric value... row F2b .f2b
          Set numeric value... row F3a .f3a
          Set numeric value... row F3b .f3b
     else
          printline: Error 'speaker$' 'begin' 'end' 'label$'
     endif
   endif
 endfor

 select .s
 plus .formant
 plus .tg
 Remove

endproc
#

printline row='row'
select tabf
Extract rows where column (text)... vowel "is not equal to"
Write to text file... formantceiling_'aantal_formanten'ALL.Table
```

Appendix 7: Pictures of vowel spaces after optimal formant measurement

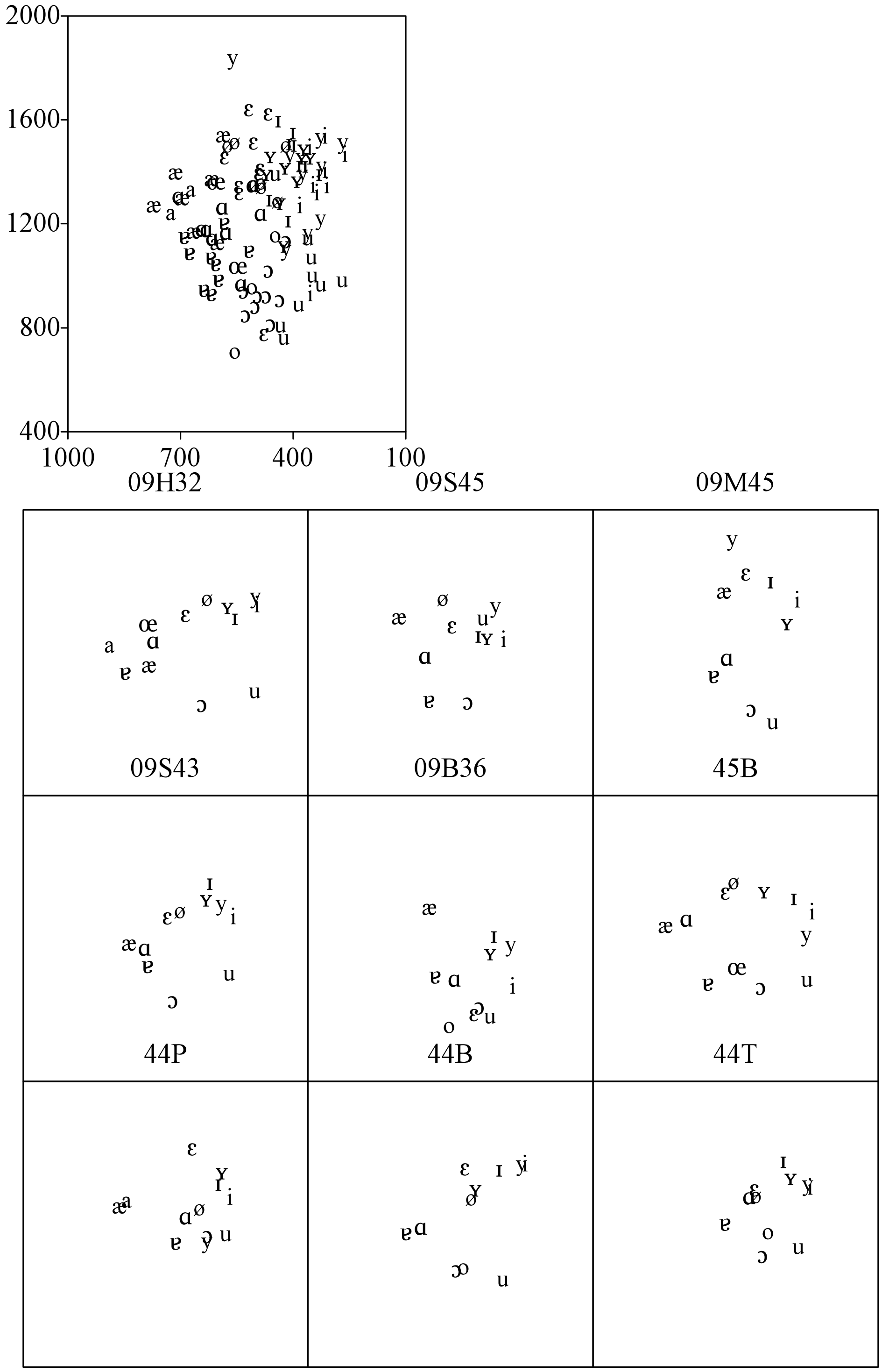
Ceiling range from 4000 Hz to 6000 Hz, 6 formants

(Formant ranges of pictures for each speaker are identical to those of the main picture)



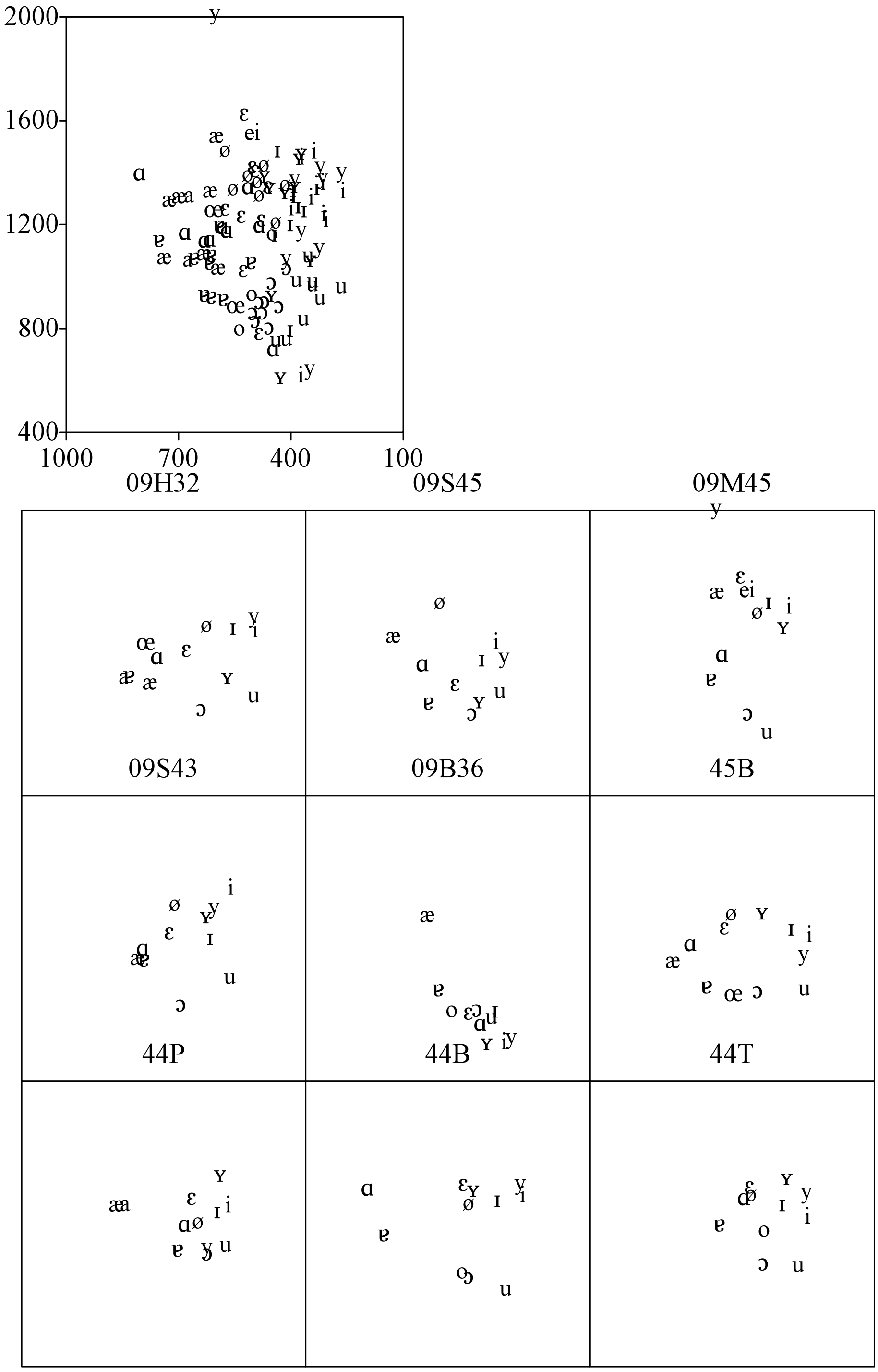
Ceiling range from 4000 Hz to 5200 Hz, 5 formants

(Formant ranges of pictures for each speaker are identical to those of the main picture)



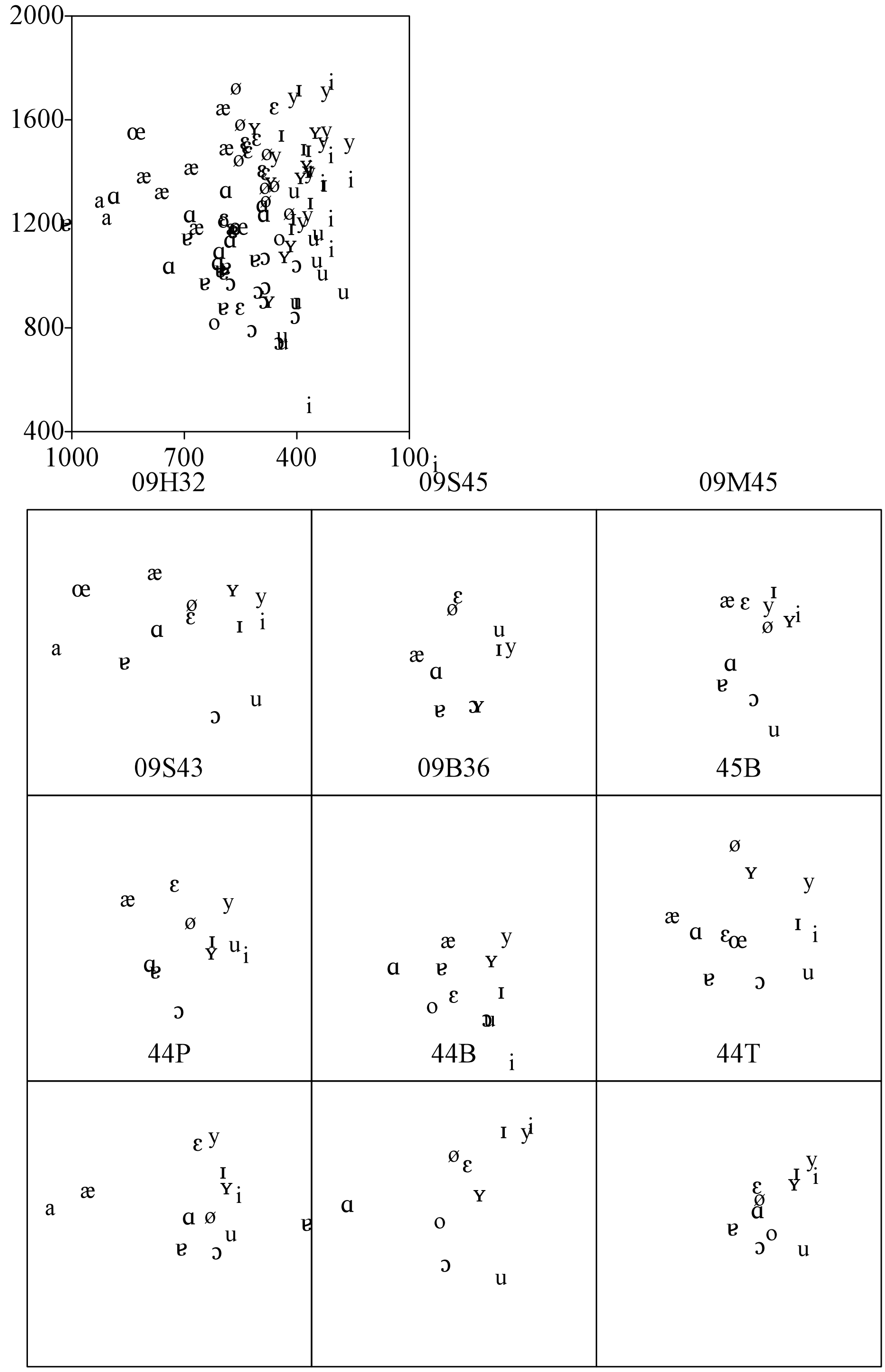
Ceiling range from 3000 Hz to 4500 Hz, 4 formants

(Formant ranges of pictures for each speaker are identical to those of the main picture)



Ceiling range from 2500 Hz to 4000 Hz, 3 formants

(Formant ranges of pictures for each speaker are identical to those of the main picture)



Ceiling range 2000 Hz to 3000 Hz, 3 formants

(Formant ranges of pictures for each speaker are identical to those of the main picture)