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The close front vowels of Northern Standard Dutch, Southern Standard Dutch and Afrikaans

A descriptive, comparative and methodological inquiry

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Master of Arts in Advanced Studies in Linguistics:
Linguistics in a Comparative Perspective

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"I love deadlines. I like the whooshing sound they make as they fly by."

As much as I love Douglas Adams, I am quite relieved, to say the least, that this particular quote of his only applied to the first submission date for my Master's thesis, and that the second deadline did not even begin to dare peer its ominous face at hopelessness' horizon. I must admit that I may have made an error of judgment, and that I gravely underestimated the man-hours needed to manually compile and statistically process a data set the size of a baby rhinoceros like the one used in the present study. This confession being made, a number of people deserve a proper 'shout-out' for their contribution to this Master's thesis, without whom it would have been impossible – or at least extremely difficult – to have successfully completed this endeavor.

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Shout-out to my long-time supervisor and now co-supervisor professor Ellen Simon as well, without whose theoretical insights in phonetics and practical tips regarding audio recordings, formant measurements and data processing the present study would have looked much bleaker and less solid.

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1 Introduction

Studies that have investigated acoustic vowel features (such as spectral quality and duration) by means of acoustic measurements have long been scarce for Dutch and Afrikaans. It is not until recently that the study of the production and perception of these acoustic features in both languages has gained considerable attention; notable studies include, among others, Adank, van Hout & Smits (2004) and Verhoeven & Van Bael (2002a&b) for Northern and/or Southern Standard Dutch (henceforth NSD and SSD, respectively), and Wissing (2011b) for Afrikaans. However, a study that compares the two European standard varieties spoken in the pluricentric Dutch language area[1] to standard Afrikaans with respect to acoustic vowel features is yet to be conducted.

The present study aims to fill this research gap, and focuses specifically on the aspect of roundedness in the rounded-unrounded close to close-mid near-front to front vowel contrasts /i - y/, /ɪ - ʏ - ə/and /e - ø/[2]. It is for these vowels that Wissing (2011b) studies the occurrence of derounding in Afrikaans. The current study hopes to present a more elaborate picture by including the SSD and NSD varieties and by working with a larger data set. A first aim then is a descriptive one, for which an account of roundedness of the relevant vowels for each language (variety) is presented[3]. In Dutch, for instance, roundedness has not yet been acoustically assessed.

[1] With NSD being the standard variety spoken in the Netherlands, and SSD the standard variety spoken in Flanders, the Dutch-speaking part of Belgium.

[2] Following the phonetic studies by Verhoeven & Van Bael (2002a&b) and Adank, van Hout & Smits (2004), the vowels /e/ and /ø/ (regarded as long vowels) will be transcribed without length mark (:) (which thus does not imply that these vowels are characterized as short vowels in the present study).

[3] The NSD and SSD varieties cannot be seen as separate languages, but as different standard varieties within the pluricentric Dutch language area. Afrikaans is generally seen as a daughter language of Dutch (but see for instance van Eeden, 1998 for a dissenting view). Nevertheless, the term 'variety' will be used throughout this study. The NSD, SSD and Afrikaans studied presently are all varieties of Dutch and Afrikaans respectively, but the use of the term is mainly for convenience's sake, so as not to always have to differentiate between the two Dutch varieties on the one hand and Afrikaans as a separate language on the other hand when referring to all three language systems. It should be pointed out that

A second aim of the study is a comparative one, for which the three varieties will be contrasted. Not only is such a comparison valuable in its own right, but it could also generate hypotheses to be used in future mutual vowel perception studies. As a third, methodological aim, the present study will assess the advantages and disadvantages of a novel type of acoustic data set for natural speech, with the aid of which the two previous aims hope to be achieved.

To place this study within its broader context, the literature review in section 2 of the current study discusses the recently increased interest in the fields of Dutch and Afrikaans acoustic vowel research, and the subsequent studies this has incited. Furthermore, comparative phonetic studies of Afrikaans and Dutch that have used a different methodological approach than the present study, as well as with research on vowel roundedness (the main focus here being on methodological aspects).

Section 3 describes the vowel systems for each variety under consideration. While rough sketches of the vowel inventories are presented, most attention will be paid to the three vowel contrasts under consideration here. Apart from these descriptions, a first brief assessment is given of the differences and similarities between the three varieties.

Section 4 presents the design of the experiment. The data gathering is discussed first, and specifically the motivation behind the nature of the data set used for this study, with attention to the potential caveats associated with this choice of data set and methodology. In the current study, the first three formants and duration for a total of 1680 vowel productions were measured for the present data set, distributed evenly over four male and four female public radio news readers in each

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no judgment whatsoever on the linguistic status of Afrikaans is implied by the use of the term 'variety' in the current study.

variety. The specifics of the vowel measurements are also discussed, as well as the vowel normalization and statistical assessment methods opted for in this study.

Section 5 presents and discusses the results. It provides an account of acoustic characteristics such as roundedness of the studied vowels as well as of the differences between the vowels within the three contrasts in each variety specifically. This mainly descriptive account is then complemented by a comparative one, so as to fulfill the second aim of this study. A comparison of the data from the present study with that from Adank, van Heuven & Smits in the last part of this section aims to answer to the comparative as well as to the methodological aim of the current study.

2 Previous research

While Labov, Yaeger & Steiner (1972a&b) were already aware of the great potential, the study of vowels by incorporation of insights and methods from acoustic phonetics (e.g., vowel formant analysis) has long been an understudied field for Dutch and Afrikaans. Van Hout, Adank & van Heuven are surprised that Labov's early work on acoustic vowel analysis did not find the adequate and appropriate support and following (2000: 150). According to the authors, a major part of the problem lies in the fact that "[p]honeticians had little or insufficient interest in language variation and sociolinguists did not have the expertise to apply programs of phonetic analysis to linguistic variation data" (2000: 150-51; my translation). It is particularly this latter study, which calls for the incorporation of acoustic measurements to strengthen empirical vowel research, that has spurred the production of a steadily growing body of literature on Dutch and Afrikaans vowels that uses a combination of phonetic and linguistic insights and methodologies to acquire a broader and more accurate picture.

In the first of three subsections, a chronological overview is given of a variety of studies that have incorporated vowel formant analyses in their studies on Dutch and Afrikaans. This serves the purpose of framing the current study within its research field, so as to better illustrate its necessity and relevance.

Afrikaans and Dutch are closely related languages, and have been studied contrastively in the past. In the second subsection, a selection of studies is presented that have compared the phonology and phonetics of Afrikaans and Dutch (through methodologies other than those used in the present study), which serves the purpose of situating the current study within the broader framework of Dutch-Afrikaans comparative phonetic research.

In a concluding section, studies will be discussed that tackle vowel roundedness specifically; since this acoustic vowel feature has not been studied acoustically for Dutch (and is limited to a few studies for Afrikaans), research on roundedness in other languages is also incorporated here. Specific attention will be paid to research methodologies, as these will be essential in determining the methodology used in the present study.

2.1 Dutch and Afrikaans: acoustic vowel research[4]

2.1.1 NSD and SSD

The lion's share of studies on Dutch that make use of vowel formant analysis did not come about until the late 1990s – early 2000s. Exceptions are two analogous studies by Pols, Tromp & Plomp (1973) and by Van Nierop, Pols & Plomp (1973). These studies measured the first three formants of twelve Dutch monophthongs produced by respectively 50 male and 30 female Dutch speakers. These studies have become "a reference frame for the acoustics of Dutch vowels" (Verhoeven & Van Bael, 2002a: 150) - not in the least because they have been, to our knowledge, the only ones in their kind for Dutch for a long time.

Driven to a considerable extent by the development of accessible speech analysis software such as the Praat program (Boersma, 2001), it became possible for non-phoneticians to engage in an accessible manner in acoustic measurement research. Around the turn of the millennium, the first modern acoustic vowel studies were published for Dutch. Schouten, Crielaard & van Dijk (1998), for instance, studied

[4] Most of the studies mentioned in this section are also discussed in a literature review paper on Dutch vowel formant measurements written for the UGent course Language Variation and Change ('*The Theoretical and Methodological Contributions of Acoustic Analyses to the Linguistic Study of Dutch Vowels: a Literature Review*'). It should be pointed out that certain parts are adapted from this paper and presented here, albeit from a perspective that is relevant to the present discussion. However, the primary sources are the same, and the similar parts in question are mostly descriptive in nature; it was therefore decided that the earlier paper would not be referenced here, and that this footnote will suffice.

[aː] and [ɑ] in the Utrecht and Amsterdam regional varieties and in Standard Dutch. The aforementioned study by Van Hout, Adank & van Heuven (2000) was not only influential for its mobilizing character, but also for its advancements in methodology. In this study, Standard Dutch is contrasted with the South Limburg regional Dutch variety spoken in Valkenburg. Apart from this comparison, which is interesting in its own right, the study also applies and evaluates several vowel normalization techniques. Due to significant differences in the size and shape of male and female vocal tracts, the absolute values of formant frequencies can differ significantly between sexes. When pooling male and female speakers together, vowel normalization techniques are needed to transform the absolute formant values to more comparable values that maintain (socio)linguistic differences, while eliminating anatomical, sex-based differences.

Verhoeven & Van Bael (2002a)[5] observe that "the acoustics of Dutch vowels ha[d] only been investigated systematically with respect to NSD", and vowel research in Flanders "ha[d] been restricted to a few impressionistic observations" (2002a: 150). In an attempt to fill this research gap, the authors measured the first and second vowel formant frequencies and duration for the twelve Dutch monophthongs produced by Limburg, Antwerp and East-Flemish speakers of (regional varieties of) SSD. The need for Standard Dutch productions led the authors to use a formal vowel reading task. The Lobanov (1971) normalization method, which uses z-score transformations of the formant values, was proven to be successful in eliminating sex-related differences while maintaining linguistically relevant information.[6] The study

[5] Verhoeven & Van Bael, 2002b is a Dutch adaptation that appeared in *Taal & Tongval* of (the working paper) Verhoeven & Van Bael, 2002a. Since the latter is written in English, the obvious choice was to cite Verhoeven & Van Bael (2002a) - for completeness' sake, both are mentioned here.

[6] This was also the method that proved to be among the best in the evaluation of a variety of vowel normalization techniques in Adank, Smits & van Hout (2004), and it is also the method used to present

confirmed and refined the hypotheses that were based on previous impressionistic observations. In doing so, Verhoeven & Van Bael (2002a&b) corroborate the claim that formant measurements are a preferable and scientifically more sound alternative to these earlier impressionistic observations.

Van Leussen, Williams & Escudero (2011) introduce a new methodological consideration when they investigate the influence of consonantal context on formant values. For this purpose, productions of NSD monophthongs by young male and female speakers were used. The results revealed considerable influence of consonantal environment on formant values, especially in the fronting of higher back vowels in alveolar contexts (2011: 1197). These findings emphasize the caution that needs to be taken when studying formants in different consonantal contexts, as is often the case in natural speech. The present study extracts its data from radio news reports in the three varieties, and thus is also prone to the considerations and conclusions made by van Leussen, Williams & Escudero (2011). In section 4, several measures are listed to limit this potential problem in the current study.

In a doctoral dissertation by Van der Harst (2011), the concept of the Vowel Space Paradox is introduced. This concept states that "[w]hereas the overall vowel space shrinks in spontaneous speech [a finding of phonetics], the individual vowels increase their vowel space by including more sociogeographic variation, without losing their identifiability [a finding of sociolinguistics]" (2011: 2). Whereas spoken news reports arguably cannot be classified as instances of spontaneous speech, it is expected that they show at least some signs of this phenomenon (especially when compared to results extracted from very formal experiments, such as word-reading or picture-naming tasks).

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parts of the results obtained in a previous BA paper and MA Thesis on vowels by the author of the present study, namely Debaene (2012) and Debaene (2013).

In Van der Harst's evaluation from the same study of no less than 17 normalization techniques, the Lobanov method again emerged as the most favorable one (Van der Harst, 2011: 91-92, 121). The main study confirmed the Vowel Space Paradox, using data from Dutch Randstad and Dutch Limburg speakers. What is of particular relevance to this study is how Van der Harst resolves the Vowel Space Paradox in the case of monophthongs. He notes that a vowel whose formant values are distinct from any of the other vowels in the vowel space can maintain its distinctive first and second formant (henceforth referred to as F1 and F2[7]) features, even if the vowel space shrinks (2011: 379). In the case of two vowels being positioned relatively close to each other, distinctions are made in other features (i.e. F3, indicative of roundedness, or vowel duration), or distinctiveness is maintained when two adjacent vowels move in the same direction (2011: 379). With regard to the current study, it will be interesting to observe how the vowels under consideration behave in the context of natural speech. Following Van der Harst, it is expected that, when mapping F1 and F2 to illustrate the vowel space in which the seven vowels studied lie, relatively large individual vowel spaces will be observed. Some overlap could even be expected, since the overall vowel space will shrink, and the vowels studied here lie relatively close to each other spectrally. Moreover, two of the three vowel contrasts studied (i.e., /i - y/ and /e - ø/) are in the same position on the IPA chart (thus sharing the same vowel space) and are only distinguished by the feature of roundedness. Keeping Van der Harst's conclusions for vowels relatively close to each other in mind, it seems interesting to assess whether derounding in Afrikaans (which would neutralize the main distinguishing feature for these vowel contrasts) causes a compensatory distinguishing on the basis of other features in these affected vowels.

[7] The third formant, also measured in the current study, is referred to as F3.

2.1.3 NSD and SSD contrasted

There are a number of studies that have compared NSD and SSD vowel data. Most notable are Adank, van Hout & Smits (2004) and Adank, van Hout & van de Velde (2007), the descriptive and comparative character of which are aimed for in this study as well. The former study presents an acoustic description of the vowels of NSD and SSD, while the latter replicated the initial study with respect to the regional varieties of Standard Dutch. In what follows, Adank, van Hout & Smits (2004) will be discussed, since it is this study that is of particular relevance to the current one as it examines the varieties also under consideration here.

One of the aims of Adank, van Hout & Smits (2004) was to update and improve the outdated reference frame for Dutch vowels that was presented in Pols, Tromp & Plomp (1973) and in Van Nierop, Pols & Plomp (1973) (cf. supra). The newly designed database includes measurements of fundamental frequency (the speed of vocal fold vibration), the first three formants and vowel duration of 15 Dutch vowels (produced by a total of 20 speakers each from the economic and cultural core regions of both speech communities)[8]. The authors felt that this update was needed because of several shortcomings in the earlier studies: dynamic vowel properties (such as duration and spectral change) were disregarded, the diphthongs /ɛɪ ɔu œy/ were not measured, and the SSD variety was not included. Furthermore, the regional backgrounds of the participants were not controlled for. Adank, van Hout & Smits revealed several differences between NSD and SSD, among which are the greater degree of diphthongization in all NSD vowels, and the longer realization of diphthongs in SSD, which the authors viewed as a compensational measure for their smaller degree of

[8] The recordings from which the database was extracted are known as the *lerarencorpus* ('teacher corpus'), which are but a small part of the *Corpus Gesproken Nederlands* ('Corpus of Spoken Dutch', henceforth CGN, cf. Oostdijk et al., 2002).

diphthongization (2004: 1737). Descriptions and findings from this study will be of importance for the discussion of the present study's results.

The experiments were conducted in a formal setting with stimuli in a fixed consonantal environment, and the authors believe it "would be interesting to compare the acoustic characteristics of the vowels of the present study with other vowel tokens produced by the same talkers in different consonantal context and speaking styles" (2004: 1737), a research gap aimed to be filled at least partly with the analysis of spoken news reports (albeit read by different speakers) in the present study.

2.1.3 Afrikaans

As is the case with Dutch, it is not until recently that acoustic measurements have started to be incorporated in research on Afrikaans vowels, the credit for which can primarily be claimed by the South-African phonetician and linguist Daan Wissing. This section gives a brief, non-exhaustive overview of acoustic research on Afrikaans vowels, which also includes several studies that have tackled derounding in Afrikaans. However, a detailed discussion of these studies is postponed until sections 2.3 and 3.3.

To our knowledge, the first study on Afrikaans vowel formants was conducted by van der Merwe *et al.* (1993). In this study, the first two formants of eight Afrikaans vowels produced by 10 male speakers are measured. One of the findings is that the overall results show consistency between speakers, adding to the evidence that formant measurements of vowels produced by speakers from a similar (socio)linguistic background can be pooled together quite well in order to generate reliable data.

Another early study (under supervision of Wissing) is Raubenheimer (1998), which focuses on an acoustic description of the Afrikaans diphthongs /ei/, /ou/ and

/ui/ specifically, and uses text reading tasks to elicit data. Wissing (2005) also focuses on diphthongs, in particular on /əi/; he calls in question the hypothesis that underlying diphthongs are only realized diphthongally. Measurements of the dynamic properties (such as spectral glide) of the first two formants of this diphthong are used to disprove this hypothesis: the results show that in almost half of the cases, this diphthong is actually produced as a monophthong. Furthermore, the spectral results lead Wissing to propose changing the phonetic transcription from/əi/ to /æɛ/.

In Wissing (2011a), the precise characteristics of the Afrikaans /u/ vowel are studied. Traditionally, this vowel has been characterized as a rounded high back vowel. Measuring the vowel in a wide array of contexts, Wissing discovered that a fronting (and derounding) change of vowel quality is taking place for Afrikaans /u/, towards a quality more akin to that of an unrounded, fronted /ʊ/ vowel. Moreover, initial observations suggested that a similar fronting process holds for the Afrikaans rounded (mid-)high back vowel /o/. This process bears some resemblance to the one taking place in British RP English, where the fronting of high back vowels is also visible in apparent time formant measurement data (e.g. Hawkins & Midgley, 2005: 186-187).

Wissing (2011b) studies the derounding tendency of Afrikaans /ʏ/, /y/ and /ø/; it is on this study that the comparative research in the current study is based. Sections 2.3 and 3.3 discuss this study in more detail. A reverse tendency, that of rounding, is observed in Wissing (2014). It was found that short /ɑ/ and long /a/ show a tendency to be rounded, especially when they precede the lateral /l/ consonant.

Another compelling, more general study is Wissing (2012a). In this study, a new and extensive framework for the scrutiny of vowels is introduced and applied to Dutch data (since the necessary measurements for Afrikaans are scarce). This framework involves acoustic as well as articulatory elements, and incorporates, among others, MRI scans of cross-sections of the head at the moment of vowel production, so as to accurately observe the precise movements and positions of the speech organs. A first application follows in Wissing (2012b), where the method was found to be successful in the analysis of the vowels of elderly female Afrikaans speakers. Another interesting conclusion is that vowel normalization again seemed unnecessary when dealing with homogeneous speaker groups, as was the case in Wissing (2012b), and which is also the case in the current study, with radio news readers being near-standard variety speakers.

Wissing (2013) is possibly the only study for the three varieties under consideration here that investigates acoustic vowel productions from the perspective of the social variable of ethnicity. The study acoustically analyses vowels produced by both white and colored female Afrikaans speakers. More specifically, it was investigated whether vowel normalization, which claims to "eliminate variation caused by physiological differences among speakers (i.e., differences in mouth sizes)", while "[preserving] sociolinguistic/dialectal/cross-linguistic differences in vowel quality" (Thomas, 2002, as cited in Thomas & Kendall, 2009), can also preserve the sociolinguistic differences in Afrikaans vowels contained in the variable of ethnicity. The results showed clear differences in vowel quality between both groups of speakers, and found that vowel normalization can indeed preserve ethnicity-based vowel differences.

2.2 Dutch and Afrikaans: phonetic comparisons

As already mentioned, a comparison of Dutch and Afrikaans using acoustic measurements has not yet been conducted. Apart from pronunciation guides and textbooks (e.g. Verdoolaege & Van Keymeulen, 2013), few studies have compared Afrikaans with Dutch on a phonetic and/or phonological level. One example of such a study is Taeldeman (1996), where parallelisms between certain consonantal features of Dutch dialects and Afrikaans are discussed. Van Keymeulen (2013) elaborates on this study, with the aim of shining light on the European Dutch background and origin of Afrikaans. A list is given of six phonological/phonetic characteristics of Afrikaans (in relation to Dutch):

> “ a. Devoicing of word-initial [v, γ, z] to [f, χ, s]
> b. Nasalized long vowels;
> c. t-deletion after obstruents;
> d. syncope of [ɣ] between a vowel and schwa;
> e. preservation (or recovering) of [sk] instead of Dutch [sχ];
> f. Rhotacism of -d- to -r-.”
>
> (adapted from Van Keymeulen, 2013: 8; my translation)

These Afrikaans characteristics are then compared to the relevant dialect maps from the FAND (*Fonologische Atlas van de Nederlandse Dialecten*, ‘Phonological Atlas of the Dutch Dialects’ – see Taeldeman, 2005 for a presentation of the project). The results showed that the hypothesis that Afrikaans originated from the Dutch coastal dialects (Hollandic, Zeelandic and Flemish) is very plausible; furthermore, some Afrikaans characteristics were shown to be closer to Flemish (a Southern Dutch dialect group) than to Hollandic (the Northern Dutch variety from which Afrikaans presumably originated). Especially this last observation is interesting in the light of the present comparison between NSD and SSD and Afrikaans.

Other studies that compare Dutch to Afrikaans on a phonetic level are van Bezooijen & Gooskens (2005) and Gooskens (2007), which study language intelligibility by using (among others) a phonetic approach, and Heeringa & de Wet (2008), which tackles phonetic aspects in its own right. These studies can be situated within the methodological field of dialectometry, the principal aim of which is a quantification of (the distances between) dialects (see Chambers & Trudgill, 1998: 137-140 for a discussion of the discipline).

Van Bezooijen & Gooskens (2005) test the intelligibility of spoken and written Afrikaans and Frisian (another West-Germanic language spoken in the north of the Netherlands) by (Northern) Dutch speakers. The results from this intelligibility experiment are then juxtaposed to measurements of the linguistic distance between Dutch on the one hand and Afrikaans and Fries on the other hand, in order to determine whether any correlation can be observed. While the measurements of lexical distance (van Bezooijen & Gooskens, 2005: 16-18) based on cognates are of lesser relevance to the present discussion, the application of the Levenshtein distance to phonetic transcriptions of these cognates in the spoken texts used in the intelligibility experiment is worth mentioning here. In short, the Levenshtein distance is "based upon the minimum number of letters or sounds that need to be inserted, deleted or substituted [weighted to a different extent] in order to transform the word in the one language into the corresponding word in the other language" (Van Bezooijen & Gooskens, 2005: 17). The results of the study showed that Afrikaans is more intelligible for Dutch listeners than Frisian. Phonetic distance proved to be a good indicator of intelligibility: "the larger the phonetic distance of a Frisian or Afrikaans word from Dutch, the harder it is for speakers of Dutch to infer its meaning"; however, even a small phonetic change can cause a failure of intelligibility, if this leads to a change in word meaning (van Bezooijen & Gooskens, 2005: 23).

Gooskens (2007) extended this research by including a case study on Danish, Swedish and Norwegian, and by also including Frisian and Afrikaans listeners in the West-Germanic experiment. Among the findings was an asymmetry in intelligibility between Dutch and Afrikaans (Afrikaans was more intelligible to Dutch listeners than vice versa); furthermore, it was shown that intelligibility "can to a large extent be predicted by phonetic distances, while [it] is less predictable on the basis of lexical distances" (Gooskens, 2007: 445).

In their research on the origin of Afrikaans pronunciation, Heeringa en de Wet (2008) use the same methodology of Levenshtein distances to calculate, in a first phase, the phonetic distance between Afrikaans on the one hand, and Dutch, Frisian and German on the other. In a second phase, phonetic distances are calculated between Afrikaans and 361 Northern and Southern Dutch dialect varieties (based on data from the RND or Reeks Nederlandse Dialectatlassen, 'Series of Dutch Dialect Atlasses'). The application of Levenshtein distances in this study differs from that of Van Bezooij & Gooskens (2005) and Gooskens (2007) in that acoustic measurements are used in this research: rather than using a binary system for measuring phonetic distance, where "non-identical phones contribute to phonetic distance, [and] identical ones do not" (2008: 161), weighting of different phones is based on acoustic similarity or dissimilarity. [9] The results revealed that Afrikaans is indeed phonetically closest to Dutch; with regard to the Dutch dialects, Afrikaans seems to be closest to the Hollandic dialects (with the variety spoken in Zoetermeer as least distant). These results are in line with the findings of Van Keymeulen (2013, cf. supra). Hollandic and

[9] It should be pointed out that the recordings used for this purpose are not in Dutch and Afrikaans, but are taken from audio material that presents the sounds of the International Phonetic Alphabet (IPA, 1995, as cited in Heeringa & de Wet, 2008). Although certainly more precise in measuring phonetic distances than a binary method, this also implies that the researchers need to keep relying on IPA transcriptions – dialect-specific phonetic subtleties revealed by acoustic measurements are thus not included (and are also unavailable, given the RND source of the data used here).

Afrikaans owe their similarity mostly to their vowels (Heeringa & de Wet, 2008: 163-164). However, this does not mean that the (features of) Afrikaans vowels examined in the current study necessarily resemble those of NSD better than those of SSD (cf. also footnote 6).

2.3 Phonetic vowel roundedness and derounding research

The purpose of this subsection is twofold. In section 2.3.1, a brief summary is given of the studies that have discussed roundedness and derounding in the three varieties under consideration in the current study. Because they are so scarce, studies on Dutch and Afrikaans that have used acoustic measurements to address the issues of roundedness and derounding are not very helpful if one wants to get a clear image of the methodological approach needed to tackle the issues at hand in the present study. Therefore, section 2.3.2 provides an overview of studies that have concentrated on roundedness and derounding in other languages, with special attention to the research methods used.

2.3.1 Roundedness and derounding in Dutch and Afrikaans

In general, the pattern found in languages is one where, as Collins & Mees state, "the front and open vowels are articulated with spread to neutral lip position, whilst back vowels have rounded lips" (2003: 67). The authors refer to Maddieson (1984), a typological study that observes this pattern in over 90% of vowel systems worldwide. Wissing reports that "Maddieson (1995) mentions only about 7% of the 535 languages investigated by him [to have non-back, rounded vowels]" (2011b: 2). Certain Dutch front vowels also display this deviating pattern, namely /ʏ/, /y/, and /ø/ (cf. Collins & Mees, 2003: 128, 132 and 134 respectively)[10].

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[10] Collins & Mees (2003) use /ʉ/ to transcribe this <put> vowel. Other studies and descriptions often refer to this vowel as /œ/ (e.g. Nooteboom, 1971, Verdoolaege & Van Keymeulen, 2013: 47). However, acoustic studies like Adank, van Hout & Smits (2004) and Verhoeven & Van Bael (2002a&b) have

The overview of studies that have observed derounding in Afrikaans as presented by Wissing reveal that this characteristic is omnipresent in Afrikaans, and that it is one of the features that distinguishes it from Dutch (1994: 122-124). Moreover, "[n]o other case of extensive presence of derounding in languages other than Afrikaans could be traced" (Wissing, 2011b: 2). Wissing (2011c) reports that derounding even occurs in Kharkams Afrikaans, an Afrikaans variety which was reported to lack this derounding. More specifically, this process can be observed in the already mentioned high front vowels /y - ʏ - ø/, so that they tend to sound like their unrounded counterparts /i - ə[11] - e/. These vowels are being derounded to such a great extent that the question even rises whether the opposition rounded-unrounded (e.g. for Afrikaans /i – y/) could be regarded as being completely neutralized for these vowels, so that only one underlying form is present for both vowels, as in the case of the voiced-voiceless distinction between Afrikaans /v – f/ (with a devoiced /v/) (Wissing, 1994: 124). Wissing (1994) discovered that colored Afrikaans speakers exhibit more derounding than white Afrikaans speakers, but finds evidence that makes him reluctant to already talk about a complete neutralization. The production and perception results in Wissing (2011b) corroborate this claim. The results from this apparent-time study (which used F2 as a measure of derounding) furthermore revealed indications of a chronolect: younger participants displayed a greater degree of derounding than older participants.

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revealed that the <put> vowel is produced with more or less the same F1 values (and thus height) as those of Dutch [ɪ]. When the IPA vowel chart is then considered, /ʏ/, which appears at the same height as /ɪ/, seems more warranted than /ʉ/ (which would be too closed) and than /œ/ (which would be too open).

[11] Cognates that are spelled with <i> are transcribed with /ɪ/ in Dutch, and with /ə/ in Afrikaans.

As already mentioned, derounding is not a process generally observed in the (more standardized varieties of[12]) Dutch. One exception is Stroop (1997). In this study, a general derounding of long vowels and diphthongs is observed as one of the characteristics of an upcoming (prestigious) variety of (Northern) Dutch, called Polder Dutch (Stroop, 1997: 19-20). What is interesting about this variety is that it is young, more 'developed' women who are reported to be spearheading this change (Stroop, 1997: 14)[13]. In a more detailed analysis, Jacobi (2009) found that age and socio-economic background (rather than gender) correlated with a change in realization of long vowels and diphthongs.

Apart from the studies by Wissing, research on roundedness and derounding in Dutch and Afrikaans are (to our knowledge) limited to auditory-based impressionistic observations. If a clear view of the methodological approach needed in the current study is to be obtained, studies on other languages will need to be taken into account, an overview of which is given in the following section.

2.3.2 Methodological approaches to roundedness and derounding

While acknowledging the complex relation between vowel acoustics (i.c. formant frequencies) and articulation, Verhoeven & Van Bael note that it is "accepted that F1 mainly correlates with articulatory degree of opening, while F2 reflects place of articulation" (2002a: 149). Low or open vowels correspond with a higher F1 frequency, while high or closed vowels correspond with a lower F1 frequency. With regard to the front-back continuum, higher F2 frequencies correspond to front vowels, while lower F2 frequencies correspond to back vowels. Figure 1.1 offers an illustration of how, when plotted correctly, F1 and F2 values can represent the classic vowel triangle fairly well.

[12] In the West-Flemish dialects, particularly those in the west of the province, derounding of /ʏ/ (so that /rʏx/ 'back' sounds like /rɪk/) is one of the characterizing ingveonisms (Devos, 2006: 38).

[13] As it happens, among Stroop's informants are also women who are employed in radio broadcasting.

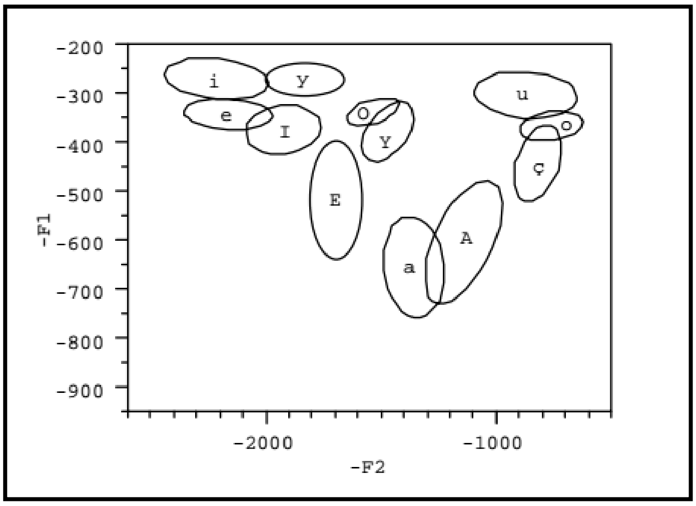

Figure 1.1. Representation of Dutch vowels (i.c. produced by Limburg men) on the basis of formant values (in Hz). Taken from Verhoeven & Van Bael (2002a: 153-154).

As already discussed in section 2.3.1, front vowels tend to be produced with spread lips, while back vowels are almost always produced rounded. This implies that F2 alone already holds information about the degree of roundedness of a vowel: the higher the value for F2, the less roundedness is to be expected. This holds true even for the Dutch rounded front vowels. According to the IPA vowel chart, the vowel contrasts /i – y/, /e – ø/ and /ɪ - ʏ/ only differ in the roundedness feature. Indeed, Ménard *et al.* (2007) also observe that "[c]ompared to /i/, the basic gesture associated with the vowel /y/ is rounding/protrusion of the lips, the tongue still being in a high and front position" (2007: 3). However, when considering Figure 1.1[14], it can be observed that, while F1 values between the contrasts are fairly similar, the rounded vowel in each of the three contrasts has consistently lower F2 values.

As already discussed, the process of Afrikaans derounding has progressed to such an extent that, for instance, even a neutralization between /i - y/ was posited (implying that /y/ nearly sounds like /i/. Relying on the discussion and Figure 1.1 in the previous paragraph, it then seems essential for a study that examines roundedness to include F2 in its analysis. The less F2 values for front rounded vowels

[14] /ø/ is transcribed with a capital O in Figure 1.1.

differ from F2 values for their front unrounded counterparts, the more likely it is that derounding occurs. It is not surprising, then, that Wissing sees F2 as the primary correlate of roundedness – and uses it as the sole measure of roundedness, with F1 only being listed to illustrate its insignificant role in this type of research (2011b: 12).

However, F2 is not the only measure that is indicative of roundedness; other studies include the F3 in their analysis. O'brien & Smith note that "F2 values are affected by both vowel height and lip rounding, the last of which generally lowers both F2 and F3 values" (2010: 299).[15] Smith & Baker use F3 as their sole measure for lip rounding (2010: 449). In a study on French (which also contains front rounded /y/), Ménard *et al.*, for instance, observe that "a [rounding/protrusion] movement of the lips lengthens the front [oral] cavity, resulting in a decrease of the affiliated formant (F3 for /i/ and F2 or F3 for /y/)" (2007: 3). To incorporate both F2 and F3 in a visual analysis of roundedness, these two formants are plotted on a scatter plane delimited by an F2 x and F3 y axis, respectively. In a study on French and Russian productions of L2 Norwegian vowels (a language that also possesses an elaborate system of front rounded vowels), van Dommelen (2007) revealed significant effects of F2 and/or F3 on roundedness as well. Estill (2012), in his analysis of the Uralic Meadow Mari language, found that F2 and F3 (he also uses F4) serve as good indicators of roundedness. Ménard *et al.* observed a lowering effect on F2 and F3 of lip protrusion - and thus rounding (2002: 1904).

[15] Although formant measurements are widely used and reasonably reliable ways of quantifying and measuring certain vowel features, nuance is still needed when inferring such articulatory features like vowel frontedness/backness and roundedness from formant values. As O'brien & Smith point out, "when the term "more front" is used in place of "higher F2 values" or "more rounded" appears for lower F3 values, these are shorthands and are not meant to imply a strict one-to-one relationship between the formant values and frontedness or roundedness" (2010: 299). Nevertheless, the authors also mention that the relation between vowel height and F1 is very straightforward (2010: 299).

From this short survey, it becomes clear that F2 and F3 are the two foremost indicators of lip rounding in vowels. While some studies rely solely on F2 or on F3 to get a picture of roundedness, most studies discussed incorporate both formants in their analysis. An analysis of these two formants then seems to be the most appropriate methodological approach in the present study. However, since a derounding process would lead the front rounded and unrounded vowels to resemble each other, there is the possibility that a potentially necessary phonemic distinction is maintained by differentiating at the level of other vowel features. Therefore, F1 and vowel duration will also be taken into account in the present study.

3 Vowels in contrast

This section discusses the characteristics of the seven vowels in the three vowel contrasts /i - y/, /ɪ - ʏ - ə/and /e - ø/, by considering previous studies that have measured and/or described these vowels. A detailed and statistical assessment of the studies is not possible due to different vowel collection and normalization methods; attention will primarily be paid here to how the vowels under consideration relate to each other. Detailed comparison will be postponed until section 5, which discusses the results of the present study.

3.1 Northern Standard Dutch

3.1.1 /i - y/

Collins & Mees characterize /i/ as a free, front, close, unrounded vowel, and /y/ as a free, front-central, between close and close-mid, rounded vowel (2003: 132). With regard to vowel duration, Booij (1995) marks /i/ and /y/ as long vowels. However, Adank, van Hout & Smits provide acoustic evidence that NSD /i/ and /y/ can in fact be grouped with the (relatively) shorter vowels (2004: 1737). Their measurements reveal comparable F1 values for both vowels, which reveal these vowels to lie highest in the vowel space (along with high back vowel /u/). It then seems that the classification of Collins & Mees of /y/ as 'between close and close-mid' can be confidently changed to 'close'. The F2 and F3 values for /y/ are lower than those for /i/, indicating a greater degree of roundedness in the former vowel. Van Leussen, Williams & Escudero also report comparable F1 values, together with lower F2 and F3 values for /y/, and provide additional evidence for grouping /i/ and /y/ with the (relatively seen) short vowels (2011: 1195). In conclusion, it appears safe to assume that roundedness is indeed the primary distinguishing feature between /i/ and /y/ (and, of course, related to this through F2, a more backed realization of /y/).

3.1.2 /ɪ - ʏ/ and /ə/

Collins & Mees characterize /ɪ/ as checked, front-central, above close-mid, unrounded, and /ʏ/ (or /ʉ/, as they transcribe it[16]) as checked, front-central, close-mid, rounded (2003: 128). As already discussed, /ʏ/ is a more favorable transcription method than /ʉ/, corroborated by the fact that F1 values for /ʏ/ are very similar to those for /ɪ/, thus warranting a transcription that implies a vowel height similar to that of /ɪ/ (Adank, van Hout & Smits, 2004: 1732 and van Leussen, Williams & Escudero, 2011: 1195). Lower F2 and F3 values for /ʏ/ observed in both studies again indicate a greater degree of roundedness for /ʏ/ than for /ɪ/. It can thus be argued that the members of this vowel contrast relate to each other in the same way as the members of the /i - y/ vowel contrast, in that roundedness is the primary distinguishing feature. /ə/ is described as "mid, central, occasionally rounded" (Collins & Mees, 2003: 128). The reason /ə/ is included here is that the cognates that are transcribed with /ɪ/ in Dutch are generally transcribed with /ə/ in Afrikaans, and it seems more complete to include Dutch /ɪ/ and /ə/ stimuli and their Afrikaans /ə/ (where Dutch would have /ɪ/) and /ə/ (where Dutch also has /ə/) counterparts in the current study.

3.1.3 /e - ø/

The close-mid free /e/ is characterized by Collins & Mees as beginning front, close-mid, ending front, above close-mid, with lips unrounded throughout (2003: 133). Close-mid free /ø/ is characterized as beginning front-central, below close-mid, ending front-central, above close-mid, with lip rounding (2003: 133). Collins & Mees classify them as narrow diphthongs, and this is one of the major differences between NSD and SSD (cf. infra in section 3.2.3). Van Leussen, Williams & Escudero (2011) do

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[16] It is surprising that Collins & Mees feel that /ʏ/ is more open than /ɪ/, but still use the /ʉ/ transcription, an IPA symbol that implies a closer realization than /ɪ/.

not report on these vowels, but Adank, van Hout & Smits once more find similar duration and F1 values and F2 and F3 values that are lower for /ø/, sketching a picture that is in line with how the other two vowel contrasts are differentiated. Collins & Mees report more open starting points for /e/ and /ø/ in the urban Dutch accents of the Randstad, which is consistent with Stroop's (1997) observations of a general lowering of these vowels in Polder Dutch (the emerging variety expected to be spoken in the central Randstad region).

3.2 Southern Standard Dutch

3.2.1 /i - y/

Van Leussen, Williams & Escudero (2011) do not report on SSD; Adank, van Hout & Smits show that the values for this vowel contrast are roughly comparable to those of their NSD counterparts (2004: 1732; albeit with a slightly longer duration, also reported in Collins & Mees, 2003: 132). This is confirmed by measurements of Verhoeven & Van Bael (2002a&b), at least for the Limburg and East-Flemish Standard Dutch varieties under consideration, which resemble each other (and the SSD variety) more than the third variety examined, namely the one spoken in the Antwerp region.[17] SSD /i/ and /y/ thus seem to relate to each other in a similar way as their NSD counterparts.

3.2.2 /ɪ - ʏ/ and /ə/

For this vowel contrast, the differences between NSD and SSD seem small (Adank, van Hout & Smits, 2004: 1732). Together with the results in Verhoeven & Van Bael this confirms a relation between the two vowels similar to that in the other contrasts, with roundedness as the primary distinguishing feature (along, of course ,with /ʏ/

[17] Spectral and temporal differences between East-Flemish and Standard Southern Dutch vowels on the one hand and Antwerp Dutch vowels on the other hand were replicated as part of the research in Debaene (2013).

being more backed, as encoded in F2). None of the acoustic studies describe /ə/, but no Northern-Southern variation is reported in Collins & Mees (2003).

3.2.3 /e - ø/

Traditionally described (and still transcribed) as steady-state monophthongs, /e/ and /ø/ are found to show diphthongal glide in NSD; in SSD, however, this glide is virtually non-existent (as shown in Adank, Van Hout & Smits, 2004: 1732 - Verhoeven & Van Bael, 2002a&b do not even control for diphthongal glide in these vowels). The different character of these vowels in NSD and SSD leads Collins & Mees to use the term 'potential diphthongs' when describing both Dutch varieties at the same time (2003: 133). Apart from the lack of a glide, similar durations and F1 values along with greater F2 and F3 values for /e/ are also observed for SSD (Adank, van Hout & Smits, 2004: 1732).

3.3 Afrikaans

Precise acoustic measurements for Afrikaans vowels are scarce; there is, however, Wissing (2012b), where the vowels of elderly (mean age = 86) women were acoustically measured. The advantage of this elderly participant group is that the case for derounding in Afrikaans becomes strong if the phenomenon (which is claimed to be a rather recent development) is also observed in this particular group of speakers. Wissing (2011b), which studies the same vowels as the ones discussed here, is also convenient, but is limited in that it only measures F2.

3.3.1 /i - y/

Verdoolaege & Van Keymeulen report an identical pronunciation of /i/ in respect to its Dutch counterpart; a similar pronunciation for Afrikaans and Dutch /y/ is also reported, but a derounding tendency is noted (2013: 47). A more robust case for derounding is made in Wissing, where very similar F2 values - more so for the younger than for the older participants - are reported for Afrikaans /i/ and /y/ (2011b: 15), indicating both derounding of /y/ and a virtual merging of the vowels on the front-back continuum. Wissing (2012b: 332) reports similar F1 values, indicating a similar vowel height; differences in F2 values are greater than reported in Wissing (2011b), and the F3 values show differences as well, which can be seen as apparent-time evidence of a derounding sound change. The three vowel contrasts as measured in Wissing (2012b: 335) display a pattern somewhat similar to that for the Dutch vowels in their F1 and F2 values.

3.3.2 /ɪ - ʏ/ and /ə/

The difference between /ə/ and /ɪ/ is said to be hardly noticeable in Afrikaans, as opposed to Dutch (Verdoolaege & Van Keymeulen, 2013: 47), which is why both Dutch /ɪ/ and /ə/ are considered in the current study, along with Afrikaans merged /ə/, as occurring in the place of both Dutch /ɪ/ as well as Dutch /ə/. Furthermore, /ʏ/ is said to be pronounced in a schwa-like manner as well (F1 and F2 values in Wissing, 2012b: 332-33 seem to back up this claim). Near-identical F1 values between /ʏ/ and /ə/ seem to warrant a transcription of /ʏ/ as /œ/; however, for clarity's and consistency's sake, a /ʏ/ transcription will be used throughout the present study. In Wissing (2011b: 15), derounding is least visible in the F2 values of this vowel contrast.

3.3.3 /e - ø/

Verdoolaege & Van Keymeulen note that Afrikaans /e/ often has a centering diphthongal quality. For /ø/, they report a pronunciation similar to that in Dutch. Similar heights for both vowels are observed in Wissing (2012b: 332). Again, derounding can be observed better in the data for younger speakers in Wissing (2011b: 15) than in the data for older speakers (Wissing, 2012b: 333). Spectral F2 (and F3) overlap is expected here (and also for the other two vowel contrasts). Following previous Dutch studies and including F1 and duration measurements in the current analysis not only provides us a more complete research, it also allows us to verify whether derounding has an effect on other features that could be used to maintain a phonemic distinction.

4 Experiment

4.1 Aims

The present experiment serves three purposes. A descriptive part of the experiment assesses whether the vowel characteristics and contrasts (as discussed in the previous section) can also be observed in a newly designed data set, for which the frequencies of the first three formants (F1, F2 and F3) and duration of the vowels in the vowel contrasts under consideration are measured. The data set comprises public radio news reports. This data set is different from those used in previous studies that are based on impressionistic observations and/or formal experiments with fixed consonantal contexts. Verifying whether the vowel descriptions derived in these manners are still observable in vowel tokens taken from natural, connected speech is an interesting endeavor in its own right (while, of course, keeping in mind and trying to minimize certain factors that could influence the results). This assessment serves the methodological purpose of the experiment.

Another aim of the study is a comparative one. The main method here is to juxtapose Afrikaans to NSD and SSD. In doing so, it can be assessed which vowels of which Dutch variety resemble their Afrikaans counterparts better, or which vowel contrasts relate to each other in a similar way. While the link between vowel production and vowel perception is not a straightforward one, tentative predictions could be made about Afrikaans vowel perception by Dutch listeners and vice versa.

4.2 Methodology

4.2.1 Design of the data set

Since the accuracy of the measurements would benefit from using a more or less uniform language variety/style, it was decided to design the data set accordingly. Therefore, news reports from national public radio stations are used, since news readers generally use a variety that is close to the standard variety, with little or no perceivable regional accent. The radio stations from which the news reports were taken included

- For NSD: Radio 1, the nationwide news and sports station of the NPO (Nederlandse Publieke Omroep, 'Dutch public broadcasting service');
- For SSD: Radio 1 and Klara, two stations of the VRT (Vlaamse Radio- en Televisieomroep, 'Flemish radio and television broadcasting service'), which broadcast in Flanders, the Dutch-speaking part of Belgium. The former covers mostly news, sports and culture in general, while the latter one is a niche station that primarily provides content on culture and plays classical music.[18]
- For Afrikaans: Radio Sonder Grense ('Radio Without Borders'), the nationwide Afrikaans public radio station of the SABC (South African Broadcasting Corporation, or Die Suid-Afrikaanse Uitsaaikorporasie).

For each variety, news reports were collected from eight (four male and four female) news readers. To reduce audio quality loss to a minimum, the news reports (taken from podcasts and live broadcasts) were recorded straight from the computer's

[18] Nevertheless, the news reports are identical in structure, and the news readers are shared between these and other VRT stations. News reports from Klara were included due to lack of suitable material from Radio 1 only.

audio card with the open source program Audacity: Free Audio Editor and Recorder (Audacity Team, 2013).

Due to the relative infrequency of certain vowels (most notably /y/ and /ø/), consonantal context was not controlled for. Together with the fact that the vowel productions were extracted from continuous speech, this leads us to expect a greater intra-vowel variability, which will be taken into account in the analysis. Nevertheless, this study is mainly of an explorative nature, and the idea is to get a broad image of vowel spaces and relations in each of the varieties. Certain measures were taken into account to improve the reliability of the results: van Leussen, Williams & Escudero, for instance, found that the group of higher front vowels (which is currently studied) is the one whose formant frequencies are least influenced by different consonantal contexts (2011: 1195, cf. also Figure 4.1 below, which includes /y/, /i/, /ʏ/ and /ɪ/). Moreover, it was decided to include variation in the consonantal contexts for each vowel, so as not to let the results be influenced by a predominance of one consonantal context for one vowel and another consonantal context for another vowel. An exception was dark /l/ ([ɫ]) at the end of words, which was avoided because of its high influence on the quality of the preceding vowel (e.g. Collins & Mees, 2003: 170). Furthermore, the relatively high amount of productions for each vowel (80 tokens per vowel per variety) is expected to increase the distinctiveness of potential patterns and improve the statistical validity of the results.

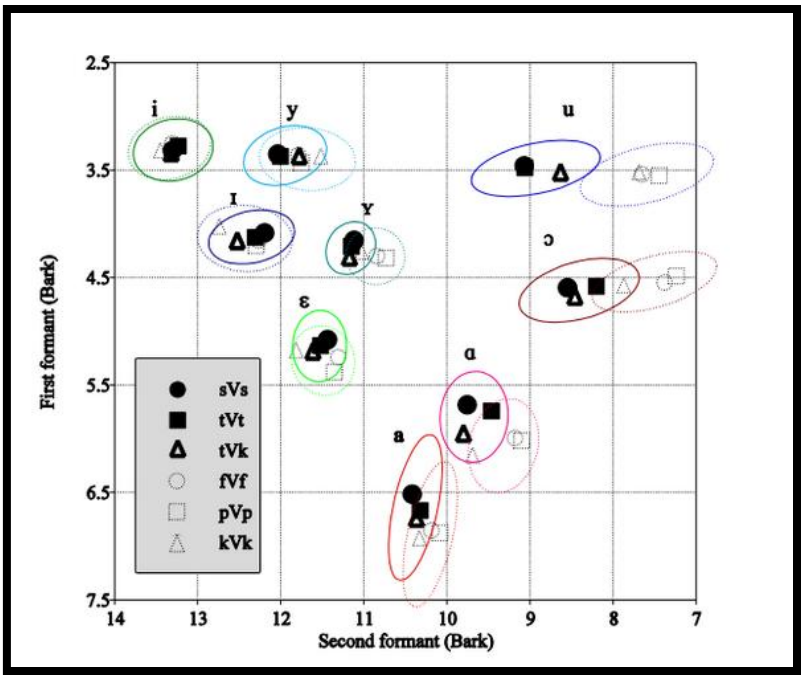

Figure 4.1. Average Bark difference metric normalized F1 and F2 values for steady-state vowels produced in different consonantal contexts by male NSD speakers. Taken from van Leussen, Williams & Escudero (2011: 1195).

News reports were recorded until enough qualitative vowel tokens were obtained for each news reader. For NSD, 40 news reports were obtained, for SSD 34, and for Afrikaans 15. Per news reader, ten tokens for each of the seven vowels (/i - y/, /ɪ - ʏ - ə/ and /e - ø/) were isolated, for a total of 560 vowel productions per variety, or 1680 vowel productions in total.

4.2.4 Coding and analysis

Once the recordings were obtained, the sound files were analyzed in Praat (Boersma, 2001). The vowel duration of the stimuli was determined through auditory analysis of the sound files along with visual analysis of the accompanying acoustic waveforms, upon which the vowel boundaries of each target vowel were marked. Subsequently, the exact middle of each vowel was determined automatically by Praat (this point was chosen to ensure a minimal influence of consonantal context). For the potential diphthongs, formant values were measured at the one third mark of the vowel, to ensure comparable values for the three varieties.[19]

At the relevant points, a formant measurement was conducted, by which F1, F2 and F3 were obtained. Praat scripts exist that automatically measure formant values, but these were not used: manually measuring each vowel ensured more accuracy and made it possible to reconsider values that could not be correct.

Most vowel normalization methods do not include F3 in their calculations. Even if they do, the goal is still a two-dimensional F1-F2 representation of the vowels in question, only nuanced by F3 values. Therefore, it was decided to only use normalization for the part of the presentation of the results that incorporates F1 and F2 (F2 being the indicator of roundedness). For this visual representation, plots generated by the NORM Vowel Normalization Suite (Thomas & Kendall, 2007) were used. For the plotting of F2 and F3 (as discussed in section 2.3.1), the non-normalized male and female results will be discussed separately, since no normalization technique can represent this particular data representation. Wissing showed that, when handling a homogenous group of speakers (such as news readers with their standard-like pronunciation), normalization is not required (2012b: 322-323).

Furthermore, as in Debaene (2013: 99-100), male and female participant results are separated for the statistical tests to ensure that sex-based differences were not biasing the results. The results will be statistically analyzed with the program RStudio (RStudio Inc., 2013). To gain a better insight in how the vowels in the vowel contrasts relate to each other, statistical tests are not only performed on the absolute values of

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[19] Due to restrictions caused by the labor-intensive character of measuring four features of 1680 vowel tokens, it was decided not to take into account diphthongal glide of /e/ and /ø/ - after all, these vowels are still transcribed with only one IPA character in the three varieties under consideration. Moreover, by measuring the vowel formants at one third of their duration, the first part of the diphthong is aimed for, which is believed to be the part resembling the SSD monophthongal vowel quality the most.

each of the vowels, but also (and predominantly) on the differences in formant and duration values between the vowels in the vowel contrasts[20]. For the former goal, Welch two-sided t-tests for equality of means are used; for the latter purpose, analyses of variance (ANOVAs) are used in combination with Tukey's HSD (Honestly Significant Difference) test for multiple comparisons of means (so that each variety can be compared to the other two varieties). It goes without saying that the present study concerns a rather limited sample, and does not represent the speech communities as a whole. Irregularities and inconsistencies are not unthinkable, and caution is still required when drawing conclusions. Nevertheless, the considerably large data set and the relatively limited groups of near-standard variety speakers from which the samples are drawn hope to contribute to a representative experiment.

The results of the measurements of duration, F1, F2 and F3 of the 1680 vowel tokens are presented in Appendix A.

4.3 Hypotheses

Keeping the discussion of the relevant vowels in section 3 in mind, this subsection gives an overview of the hypotheses to be tested and the results to be expected.

4.3.1 /i – y/

For this vowel contrast, no great differences are expected between NSD and SSD results (apart from a potentially longer duration of SSD vowels). Similar F1 values for both vowels would disprove the characterization of these vowels by Collins & Mees (2003: 132) as having a different height; the other two formant values are also expected to be more or less similar across both varieties. F2 and F3 values (and thus a

[20] Per variety and speaker, the results of each of the ten vowel productions of vowel a in the contrast were subtracted from each of the ten vowel productions of vowel b. Taking the absolute values of these differences provides us with the distance between vowel a and b for each of the four features under consideration.

greater degree of roundedness) are expected to be lower for /y/ than for /i/ in both varieties.

For Afrikaans, both the F2 and F3 values for /i/ and // are expected to lie relatively closer, indicating derounding. Concretely, it is /y/ that is expected to be more fronted and derounded, illustrated by higher F2 and F3 values. Since the values of /i/ and /y/ are expected to be rather similar in both varieties of Dutch, a tendency of Afrikaans to adhere to one of both varieties is not expected. However, the derounding tendency of vowels in the Polder Dutch variety spoken by the female speaker group (to which the participants of this study possibly belong) could cause a greater similarity of these Afrikaans vowels to NSD than to SSD.

4.3.2 /ɪ - ʏ/ and /ə/

NSD and SSD /ɪ/ and /ʏ/ are expected to relate to each other in a similar way as /i/ and /y/. Concretely, similar F1 values are expected to indicate a similar vowel height, with lower F2 and F3 values for /ʏ/ indicating a greater degree of backness and roundedness. The emerging Polder Dutch variety could lead to lower F2 and F3 values for /ʏ/ and thus a greater degree of derounding. Although no previous data is available for /ə/, no great differences are expected between NSD and SSD, if the descriptions of the previous checked, short, steady-state vowels are followed. Since /ə/ is produced central, both for height and for frontedness/backness, a greater deal of intra-vowel variation is expected than for the other vowels in this study, which lie closer to the borders of the vowel space.

As for Afrikaans, the values for /ʏ/, /ɪ/ and /ə/ are expected to lie close to each other, since both /ɪ/ (transcribed as /ə/) and /ʏ/ are reported to have a schwa-like realization. The convergence of these three vowels could explain why the least amount of derounding is expected in this vowel contrast.

4.3.3 /e - ø/

More differences are expected between NSD and SSD /e/ and /ø/ (although the limited extent of this study and the labor-intensive character of manual measurements did not allow for the inclusion of diphthongal glide in the analysis[21]).

As for Afrikaans, /e/ and /ø/ seem more similar to their NSD counterparts, in the sense that these vowels also have a (different) diphthongal character (which could not be studied in the current study[22]). /ø/ is reported to be similar to its Dutch counterparts, but this could be disproven by the observation of an Afrikaans derounding tendency in this vowel as well. Similar F1 values for Afrikaans /e/ and /ø/ are also predicted. Due to derounding, spectral F2 and F3 overlap is expected (as for the other two Afrikaans vowel contrasts). Of the three vowel contrasts examined in this study, /e - ø/ is expected to differ the most across all three varieties mutually.

[21] As was the case in Verhoeven & Van Bael (2002a&b) for SSD, and Wissing, (2011b & 2012b) for Afrikaans, where diphthongal glide of these vowels was not included in the analysis either.

[22] However, the diphthongal character of Afrikaans /e/ and /ø/ was impressionistically observed while analyzing the news reports in Praat.

5 Results and discussion

This section presents and discusses the results of the vowel measurements obtained in the experiment described in section 4. In what follows, the vowel space (i.e. F1-F2 plane) [23], duration and F2-F3 plane is discussed for each of the three vowel contrasts under consideration in the present study.

5.1 Vowel contrasts

5.1.1 /i - y/

For this vowel contrast, it was hypothesized that NSD and SSD would be closer to each other than to Afrikaans, in which a vowel convergence on the F2 axis would indicate derounding. This is indeed the picture that is revealed in Figure 5.1, in which the F2 values of Afrikaans /i/ and /y/ are shown to be very close. Apart from Afrikaans /y/ having a greater average F2 value than its Dutch counterparts, Afrikaans /i/ also has a smaller average F2 value, which, together with the standard deviation ellipses, could indicate that a merger of these two vowels is taking place in Afrikaans. What is striking is that the F2 value of Afrikaans /y/ is even greater than that of Afrikaans /i/, suggesting that /y/ is even more derounded than /i/. With regard to the Dutch varieties, /i/ and /y/ relate to each other in a fairly similar way, apart from the difference in vowel height being more pronounced in SSD.

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[23] Since the NORM Vowel Normalization and Plotting Suite that is used to present these particular results does not support IPA characters, X-SAMPA notations are used; /i - y/, /ɪ - ə - ʏ/ and /e - ø/ are thus represented as /i - y/, /I - @ - Y/ and /e - 2/, respectively.

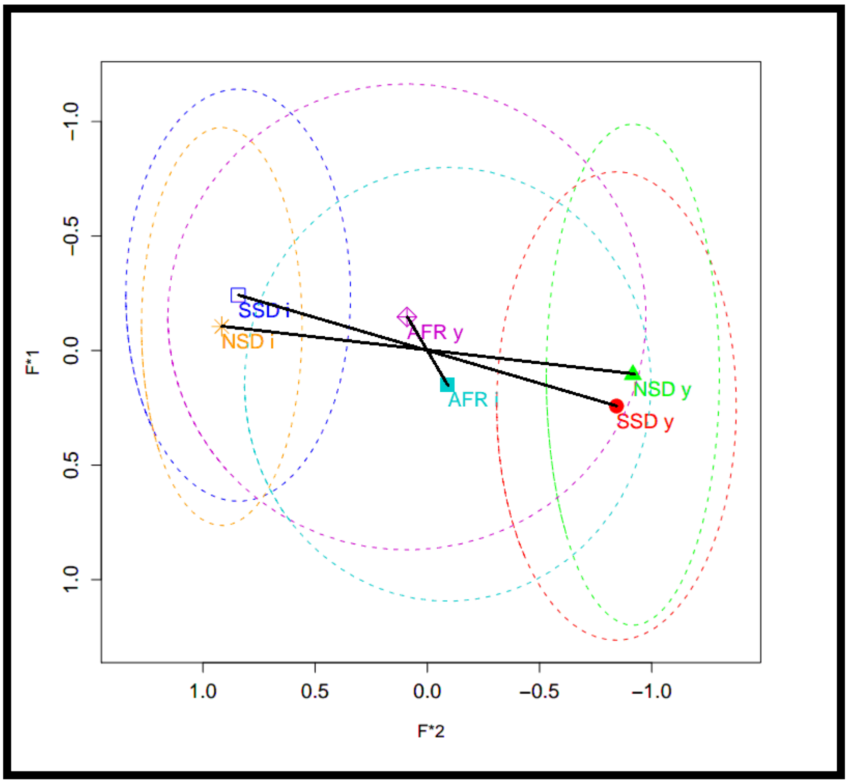
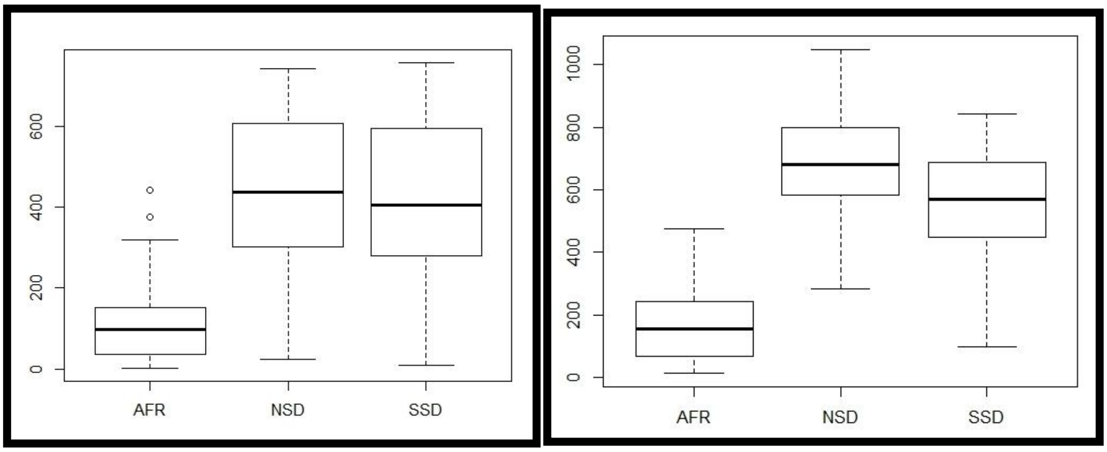


Figure 5.1. Lobanov normalized average production of NSD, SSD and Afrikaans (AFR) /i - y/. Ellipses indicate the standard deviations. For clarity's sake, the vowel contrasts in each variety are connected in this particular figure.

Table 5.1, which presents the p-values for Tukey's HSD test for /i - y/ differences, largely confirms these observations. Significant differences between Afrikaans on the one hand and the two Dutch varieties on the other hand are predominantly found for the difference in F2, which is illustrated by the box plots in Figures 5.2 and 5.3, and for the difference in F3. As predicted, the F1 feature does not play a distinguishing role in the cross-linguistic comparison.

Box plots for all within-language vowel contrast differences are presented in Appendix C.



Figures 5.2 and 5.3. Box plots of the F2 differences for male (left) and female (right) AFR, NSD and SSD /i / and /y/.

As for duration, Table 5.1 reveals no significant cross-linguistic differences, which is consistent with Figure 5.4, which reveals that it is not only the way in which /i/ and /y/ relate to each other that is very similar cross-linguistically, but also the absolute duration values.

Screenshots for the ANOVA's and Tukey's HSD tests conducted (on which tables 5.1 to 5.5 are based) are presented in Appendix D; the box plots used to visualize the data on which the statistical calculations are based are presented in Appendix E.

Table 5.1. p-values for Tukey's HSD test for cross-linguistic /i - y/ differences. A significant result indicates that the null hypothesis (i.e. there is no significant difference in means between variety A and variety B for this feature difference) is to be rejected in favor of the alternative hypothesis (there is a significant difference in means between variety A and variety B for this feature difference). Tendencies (0.10 > p > 0.05) are indicated in orange, significant results (0.05 > p > 0.01) are indicated in green; highly significant results (p < 0.01) are indicated in green, bold and italics (significance levels adopted from Triest, 2009). These table-reading guidelines also apply to tables 5.2 to 5.5.

/i - y/					
Varieties	**sex**	**F1 (p)**	**F2 (p)**	**F3 (p)**	**Duration (p)**
NSD x AFR	Male	0.924	***< 0.001***	0.520	0.370
	Female	0.015	***< 0.001***	***< 0.001***	0.986
SSD x AFR	Male	0.229	***< 0.001***	0.059	0.130
	Female	0.158	***< 0.001***	***< 0.001***	0.870
SSD x NSD	Male	0.413	0.768	0.446	0.822
	Female	0.596	***0.001***	0.015	0.784

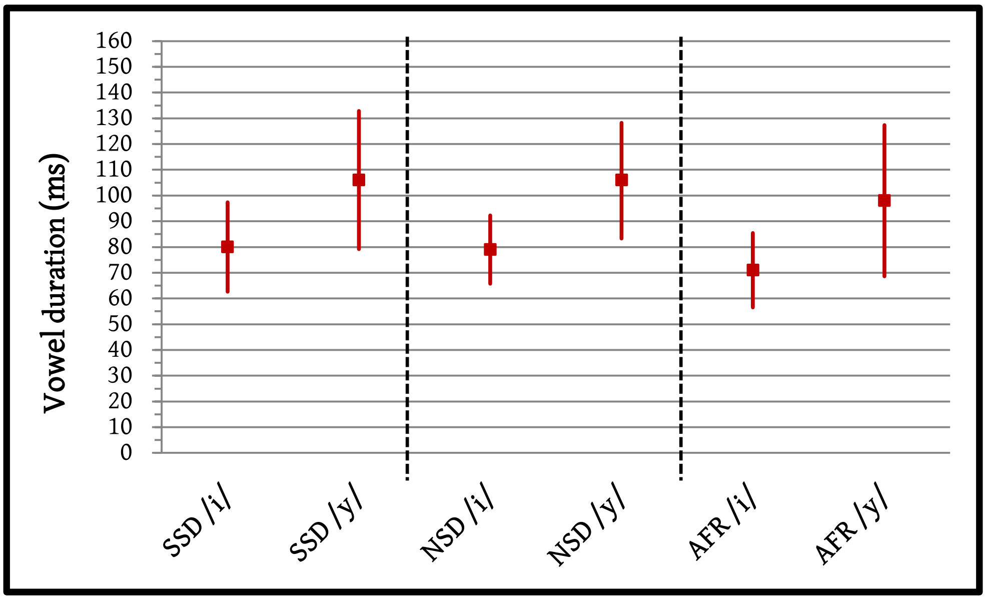
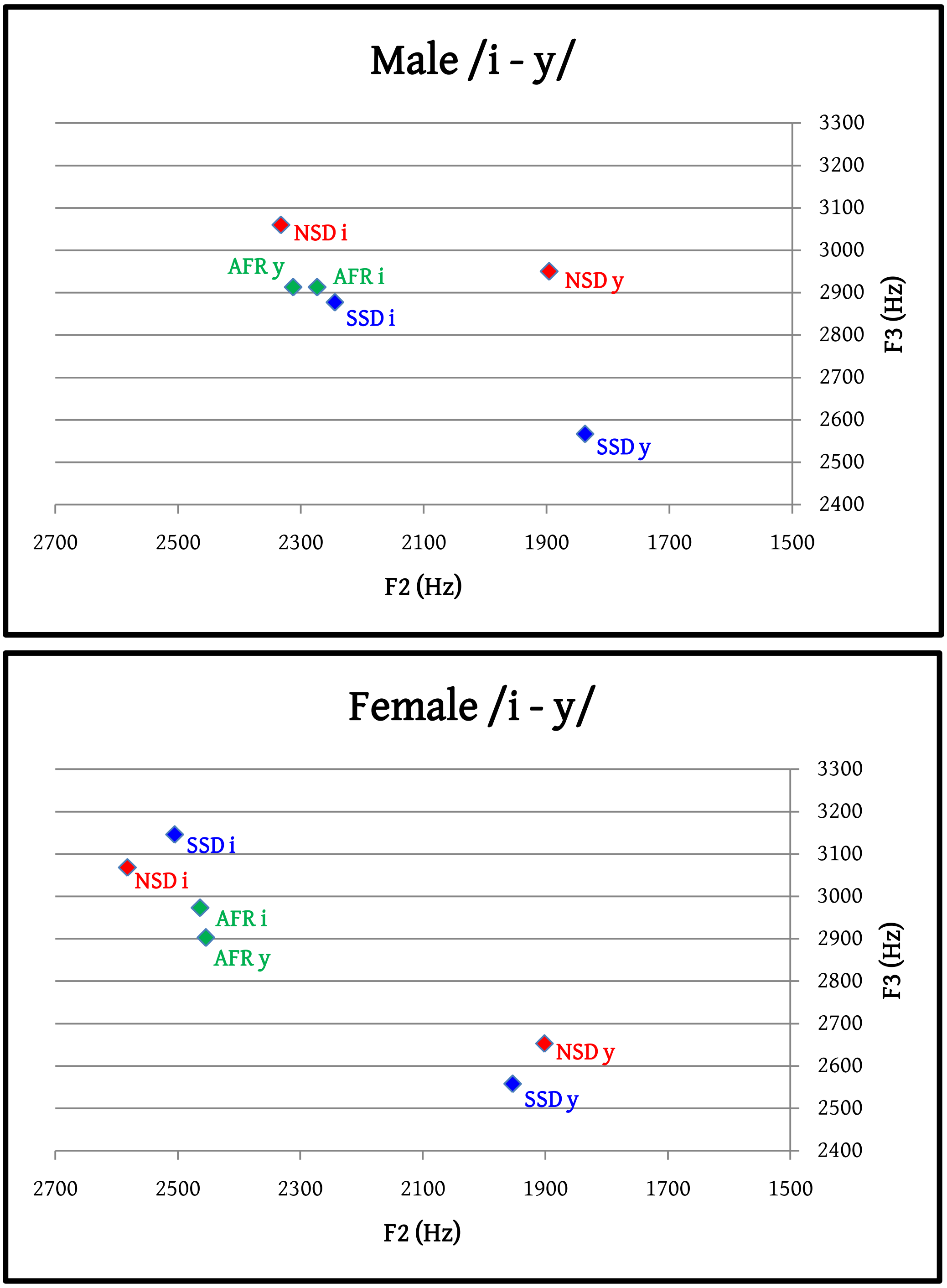


Figure 5.4. Average vowel duration of /i/ and /y/ for SSD, NSD and AFR. The vertical lines indicate a distance of 1 standard deviation from the average.

As for the assessment of derounding, for which a combined representation of F2 and F3 is used, the picture that emerges from Figures 5.5 and 5.6 is clear-cut: Afrikaans /y/ is indeed derounded, to such an extent even that it seems to have merged with Afrikaans /i/ with regard to F2 and F3 features. A much clearer distinction is visible for both NSD and SSD, of which the vowels moreover relate to each other in a fairly comparable way. No evidence is found in the female results for the Polder Dutch derounding tendency. Although the F2 and F3 differences between NSD and SSD male /i/ and /y/ do not differ significantly, the NSD vowels do possess higher F2 and especially F3 absolute values than their SSD counterparts, indicating a more derounded character for both these vowels.



Figures 5.5 and 5.6. F2-F3 plane with the average values of respectively male and female /i - y/ in SSD, NSD and AFR.[24]

[24] The results are presented in this particular way - with the F2 axis ascending from right to left – in correspondence to F1-F2 planes, and bearing the IPA vowel chart in mind: the higher the F2 value, the more fronted a vowel, and thus the more to the left in the IPA vowel chart the vowel will be positioned.

5.1.2 /ɪ - ʏ/ and /ə/

For /ɪ - ʏ/, Figure 5.7 reveals a similar picture as for /i - y/, with SSD and NSD /i - y/ indeed being contrasted in a very similar way, that is furthermore quite different from the way these vowels are contrasted in Afrikaans. This is confirmed by the p-values in Table 5.2 below, where significant differences are predominantly found in the difference between Afrikaans on the one hand and NSD and SSD on the other, with almost no significant differences in the features when comparing both Dutch varieties. The F2 value of Afrikaans /ʏ/ is still smaller than that of Afrikaans /ɪ/ (as opposed to Afrikaans /y/ and /i/). This is consistent with Wissing (2011b: 15), where a lesser degree of derounding in the /ɪ - ʏ/ contrast was reported.

What the picture for /i – y/ and /ɪ - ʏ/ reveals is that the derounding process in Afrikaans consists of a convergence of both vowels toward each other (when compared with the Dutch varieties), with especially F2 and F3 values converging towards each other. This adds to the derounding picture the nuance that, instead of the rounded vowels /y/ and /ʏ/ merely being more derounded than their Dutch counterparts, the unrounded Afrikaans vowels /i/ and /y/ are also less derounded than their Dutch counterparts. Welch's two-sided t-tests (used to test within-variety differences) revealed no significant differences for male (t = 1.6895, df = 77.994, p-value = 0.09511), nor for female speakers' (t = 0.6202, df = 76.365, p-value = 0.537) F1 values of Afrikaans /i/ and /y/. The same goes for the /ɪ - ʏ/ contrast, where the F1 values for male (t= 1.186, df = 76.060, p-value = 0.239), and female speakers (t = 0.073, df = 77.454, p-value = 0.942) did not differ significantly for Afrikaans /ɪ/ and /ʏ/. This indicates that on a spectral level (i.e. for the F1, F2 and F3 features), the vowels in these two vowel contrasts show evidence of merging; future perception experiments could reveal if the acoustic similarity is reflected in the perception of these vowel contrasts. The results of all Welch's two-sided t-tests are presented in Appendix B.

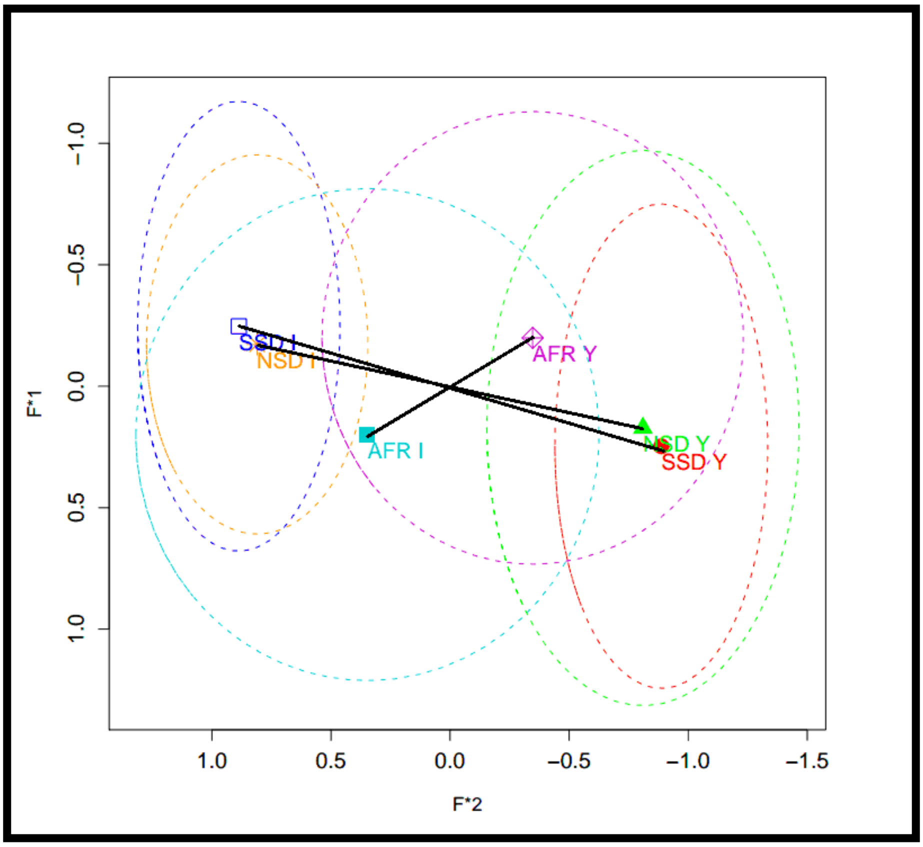


Figure 5.7. Lobanov normalized average production of NSD, SSD and Afrikaans (AFR) /ɪ - ʏ/. The ellipses indicate the standard deviations. The vowel contrasts in each variety are connected for clarity's sake in this particular figure.

As for duration, Tables 5.2, 5.3 and 5.4 reveal only one significant cross-linguistic difference in eighteen tests conducted for the combinations of the three vowels in this vowel contrast. Figure 5.8 indeed reveals similar relationships between the absolute values of the durations of the three vowels for each variety. For Afrikaans, the differences in duration for male (t = -4.7515, df = 77.287, p-value = <0.001) and female (t = -5.5588, df = 69.489, p-value = <0.001) /ɪ/ and /ʏ/ are significant, as are the differences in duration for male (t = -5.4895, df = 50.621, p-value = <0.001) and female (t = -5.1763, df = 66.547, p-value = <0.001) /i/ and /y/. It thus seems that of the four features investigated, duration remains the only distinguishing feature between /i - y/ and /ɪ - ʏ/ - spectral differences between these vowel contrasts have become minimal.

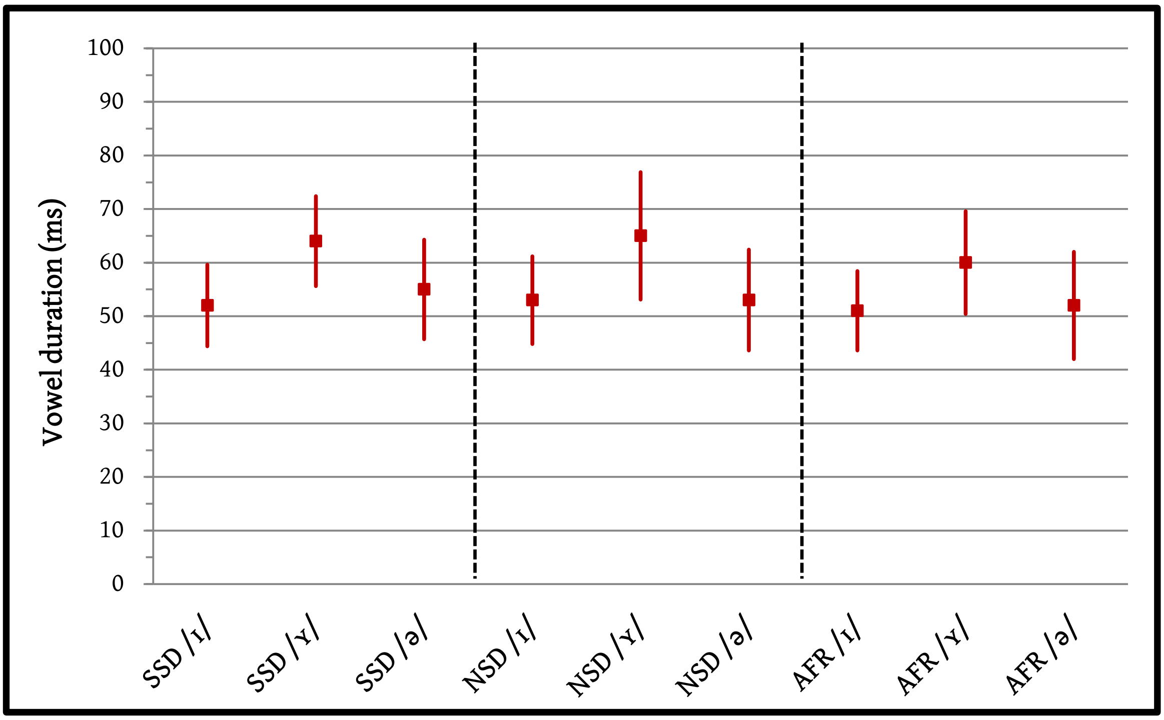


Figure 5.8. Average vowel duration of /ɪ/, /ʏ/ and /ə/ for SSD, NSD and AFR. The vertical lines indicate a distance of 1 standard deviation from the average.

Tables 5.2, 5.3 and 5.4. p-values for Tukey's HSD test for cross-linguistic /ɪ - ʏ/, /ʏ - ə/ and /ɪ - ə/ differences respectively.

/ɪ - ʏ/					
varieties	sex	F1 (p)	F2 (p)	F3 (p)	Duration (p)
NSD x AFR	Male	***0.007***	0.041	0.056	0.275
	Female	0.036	***< 0.001***	0.428	0.194
SSD x AFR	Male	0.010	***0.001***	0.010	0.449
	Female	0.054	***< 0.001***	***< 0.001***	0.598
SSD x NSD	Male	0.993	0.483	0.789	0.941
	Female	0.985	0.935	***< 0.001***	0.719

/ɣ - ə/					
varieties	sex	F1 (p)	F2 (p)	F3 (p)	Duration (p)
NSD x AFR	Male	0.128	0.983	0.108	0.034
	Female	0.457	0.128	*< 0.001*	0.986
SSD x AFR	Male	0.029	0.443	0.999	0.882
	Female	0.591	0.019	*< 0.001*	0.338
SSD x NSD	Male	0.804	0.550	0.116	0.106
	Female	0.974	0.712	0.236	0.262

/ɪ - ə/					
varieties	sex	F1 (p)	F2 (p)	F3 (p)	Duration (p)
NSD x AFR	Male	0.049	0.085	0.108	0.991
	Female	0.016	*< 0.001*	0.999	0.872
SSD x AFR	Male	*0.007*	0.047	*0.005*	0.305
	Female	0.264	*< 0.001*	0.932	0.745
SSD x NSD	Male	0.767	0.966	0.490	0.370
	Female	0.434	0.846	0.925	0.438

As for the observation that Afrikaans /ɪ - ɣ - ə/ are pronounced in a schwa-like manner, Figure 5.9, which shows a great spectral overlap between these three Afrikaans vowels, confirms this picture of a merging tendency. Like Afrikaans /ɣ/, Afrikaans /ə/ also displays a greater degree of derounding than its Dutch counterparts. The greater standard deviation ellipses for the three schwas also confirm the prediction of greater intra-vowel variability for this particular vowel. Moreover, this figure also reveals that /ɣ/ and /ə/ lie very close to each other on a spectral level in each variety - especially in both Dutch varieties.

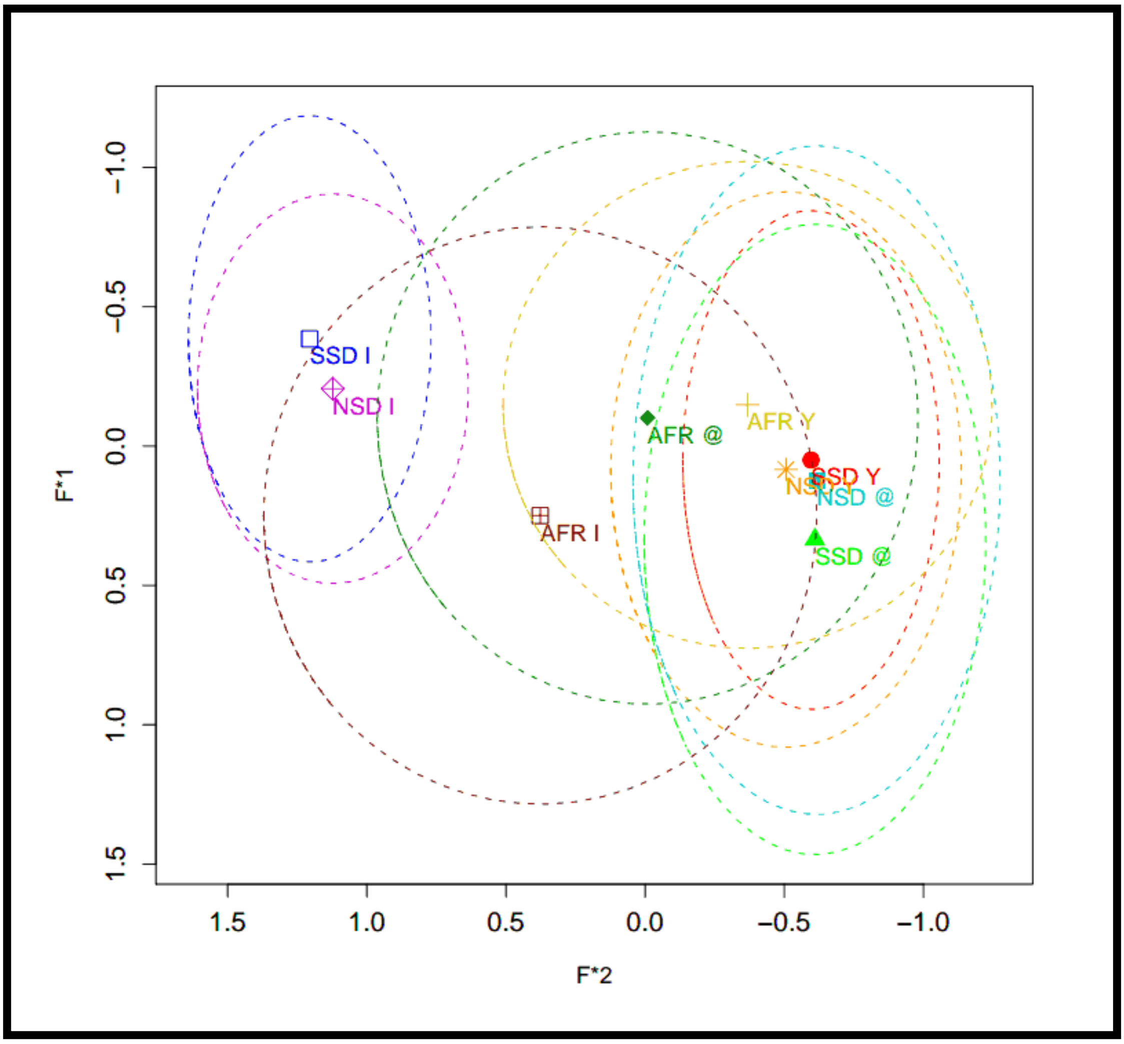
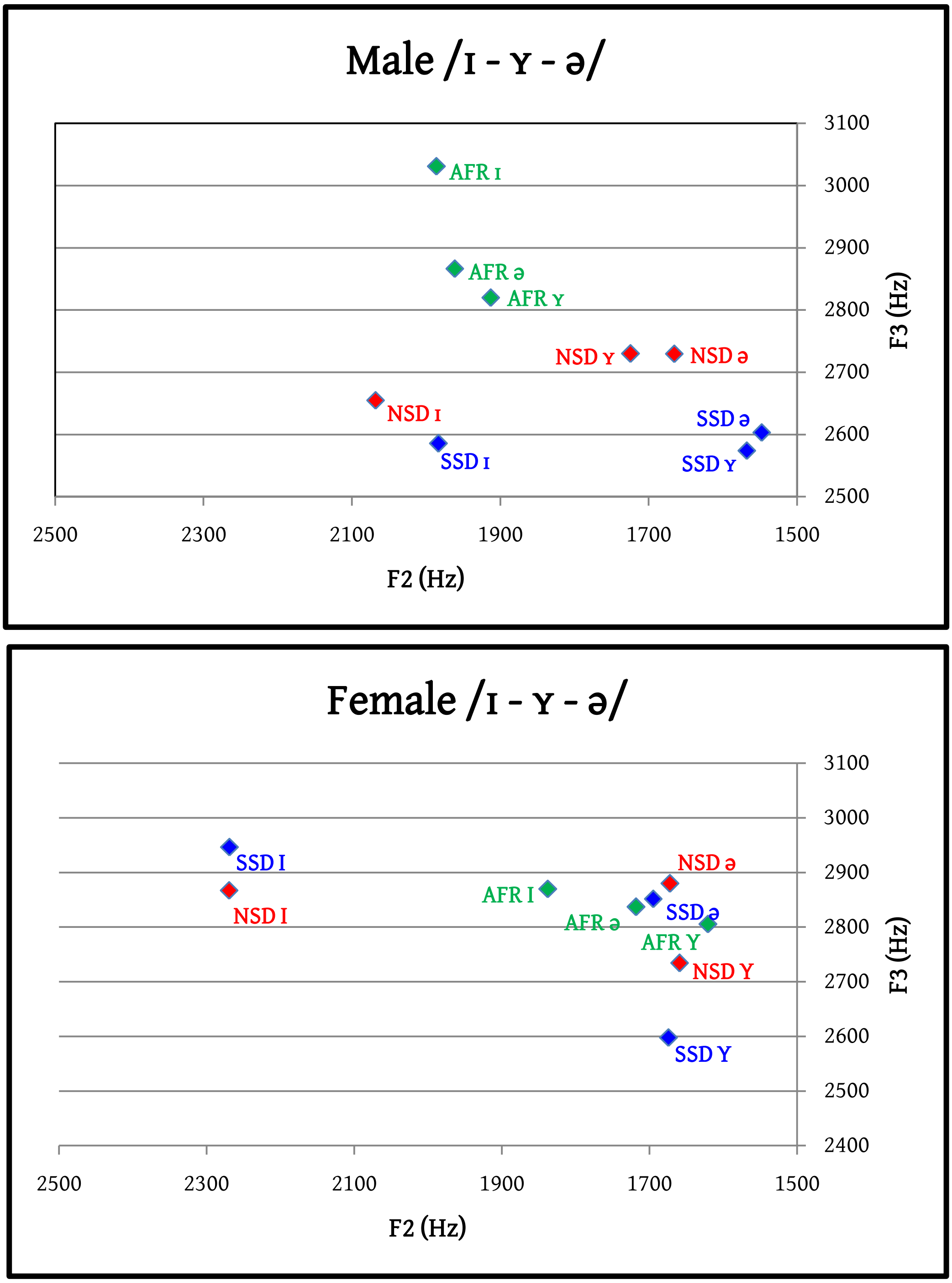


Figure 5.9. Lobanov normalized average production of NSD, SSD and Afrikaans (AFR) /ɪ - ʏ - ə/. Ellipses indicate the standard deviations.

Figures 5.10 and 5.11, which present the F2-F3 planes, confirm the derounding and merging tendency of Afrikaans /ɪ - ʏ - ə/, especially in comparison with the Dutch counterparts. Furthermore, greater F2 and F3 values for the male vowels (and, to a more limited extent, for female vowels) in NSD in comparison with SSD could be a sign of the derounding tendency mentioned in Stroop (1997). That male results display this to a greater extent than female results seems at first surprising, as Stroop (1997) described this as a predominantly female phenomenon. However, one should keep in mind Jacobi's (2009) research, which revealed that age and socio-economic background (rather than gender) were decisive factors.



Figures 5.10 and 5.11. F2-F3 plane with the average values of respectively male and female /ɪ - ʏ - ə/ in SSD, NSD and AFR.

5.1.3 /e - ø/

As is the case for the two other vowel contrasts, an indication of merging of /e - ø/ and derounding of /ø/ is visible in the Afrikaans results (cf. Figure 5.12) – again, the F2 values of the Afrikaans vowels lie considerably closer than those of their Dutch counterparts, of which both varieties behave fairly similar. However, when taking standard deviations into consideration, NSD /e/ and /ø/ seem to be positioned closer to each other, which could be caused by the derounding tendency in this variety of Dutch, as discussed in Stroop (1997)[25]. Table 5.5 reveals that it is the /e - ø/ contrast that differs the most cross-linguistically, for each combination of varieties. This is in line with the hypotheses from section 4.3.3, and it is also consistent with observations in Adank, van Hout & Smits (2004) - which reveal differences between NSD and SSD /e/ and /ø/ - and those in Wissing (2011b) and Verdoolaege & Van Keymeulen (2013), in which acoustic descriptions of the Afrikaans diphthongal character of /e/ and /ø/ are given that differ from both Dutch varieties.

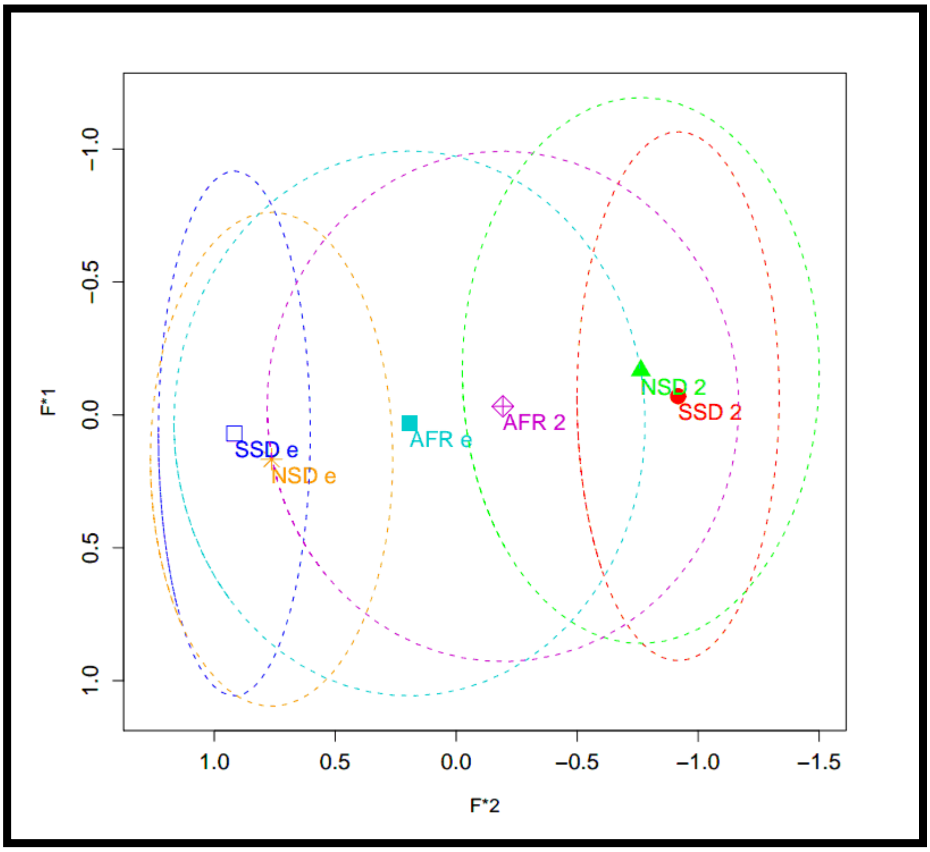


Figure 5.12. Lobanov normalized average production of NSD, SSD and Afrikaans (AFR) /e - ø/. The ellipses indicate the standard deviations. The vowel contrasts in each variety are connected for clarity's sake.

[25] Cf. also the relevant box plots in Appendix E.

Table 5.5. p-values for Tukey's HSD test for cross-linguistic /e - ø/ differences.

/e – ø/					
varieties	sex	F1 (p)	F2 (p)	F3 (p)	Duration (p)
NSD x AFR	Male	0.025	0.217	0.010	0.982
	Female	*0.001*	*<0.001*	*<0.001*	0.986
SSD x AFR	Male	0.675	*<0.001*	*<0.001*	0.829
	Female	0.904	*<0.001*	*<0.001*	0.824
SSD x NSD	Male	*0.002*	*<0.001*	0.724	0.915
	Female	*0.006*	0.256	*<0.001*	0.903

Table 5.5, in combination with Figure 5.13, again reveal no significant cross-linguistic differences regarding vowel duration. When considering the vowel durations of all seven vowels examined in the current study (as illustrated in Figure 14), it becomes clear that duration is not a distinguishing factor, cross-linguistically, and that the way these vowels relate to each other on a durational level is very similar in the three varieties. The generally longer duration of SSD as opposed to NSD, as reported by Adank, van Hout & Smits (2004), is not visible in the present sample.

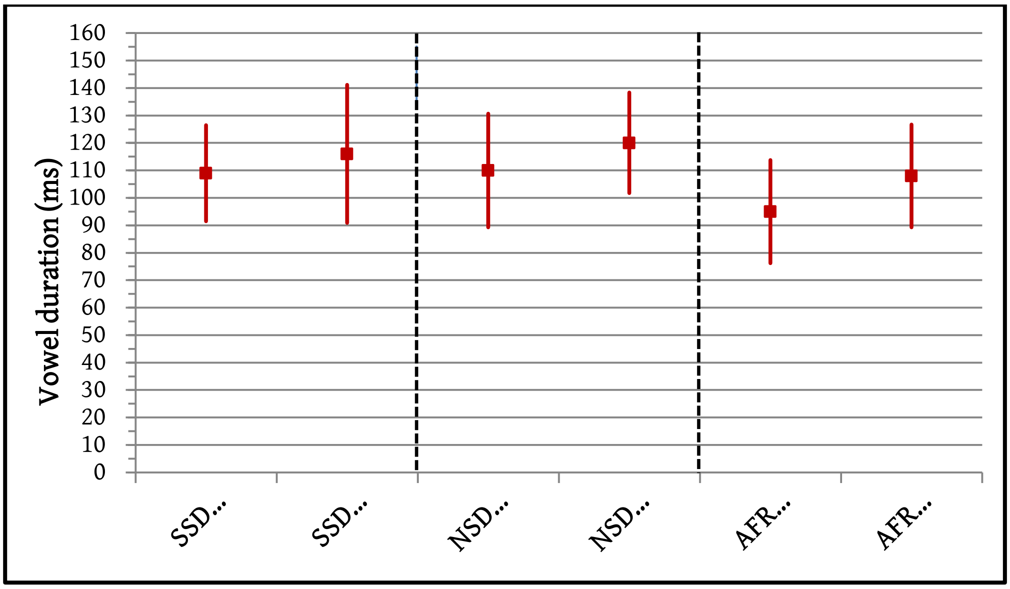


Figure 5.13. Average vowel duration of /e/ and /ø/ for SSD, NSD and AFR. The vertical lines indicate a distance of 1 standard deviation from the average.

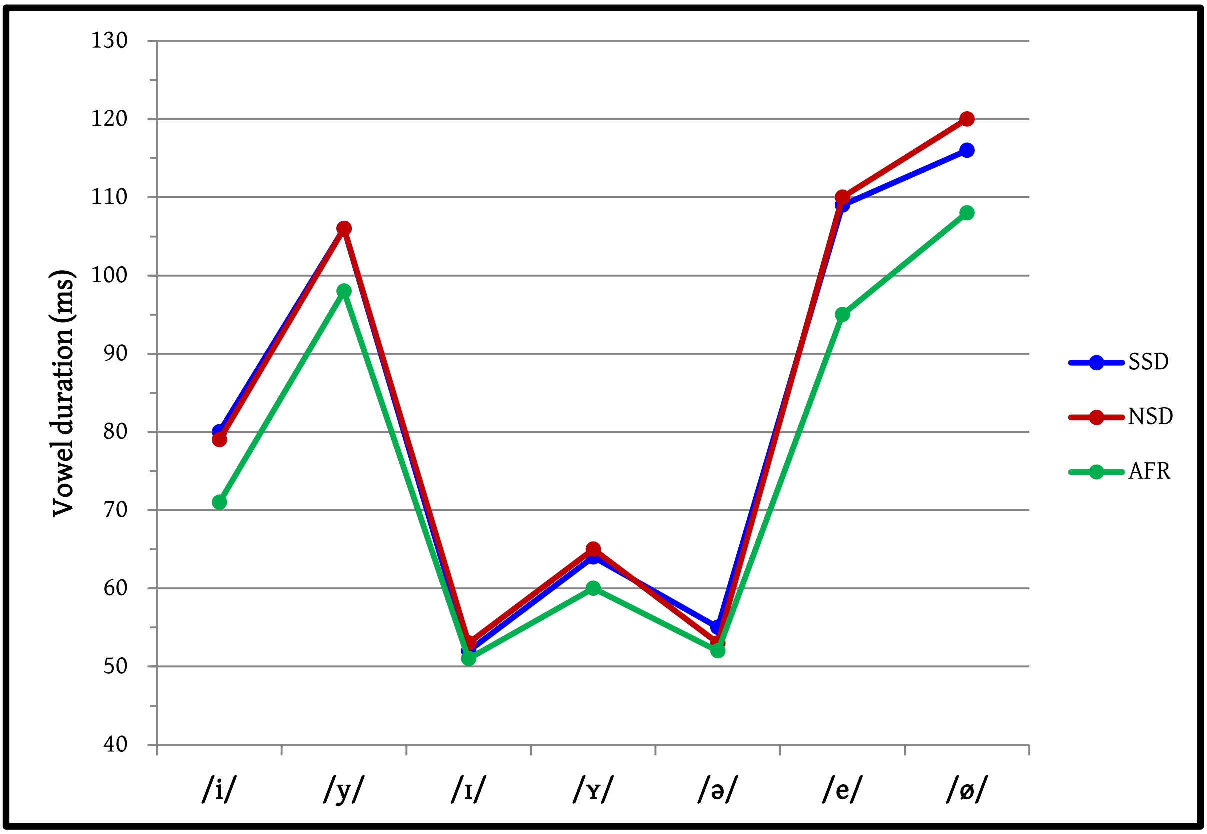


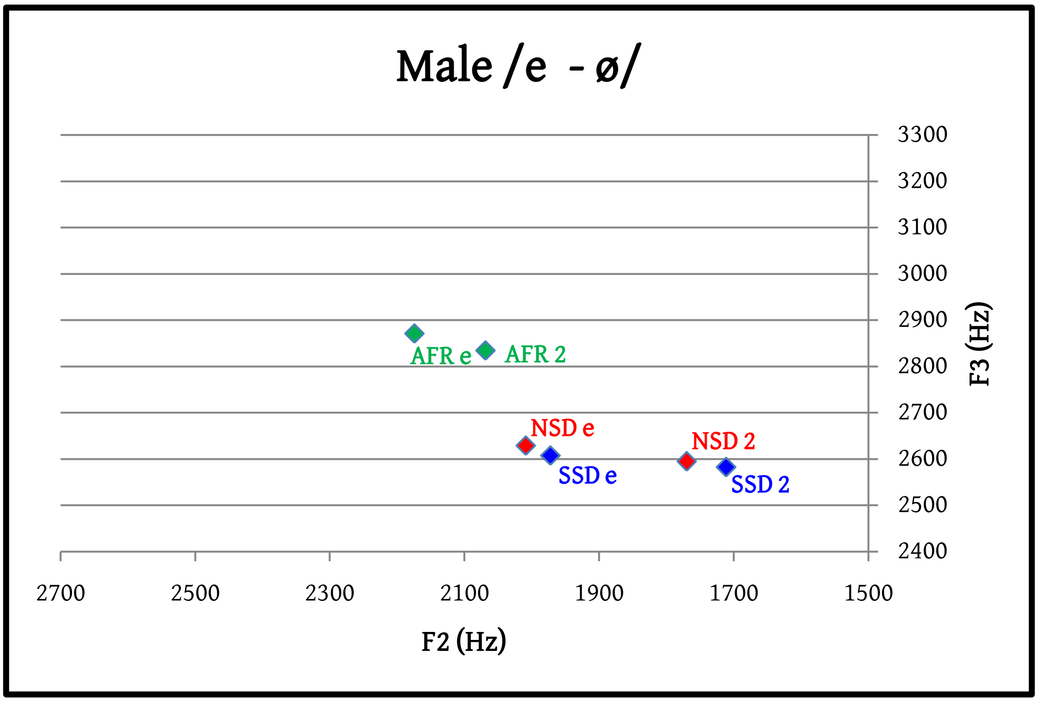
Figure5.14. Average durations for the seven vowels from the three vowel contrasts examined in the present study.

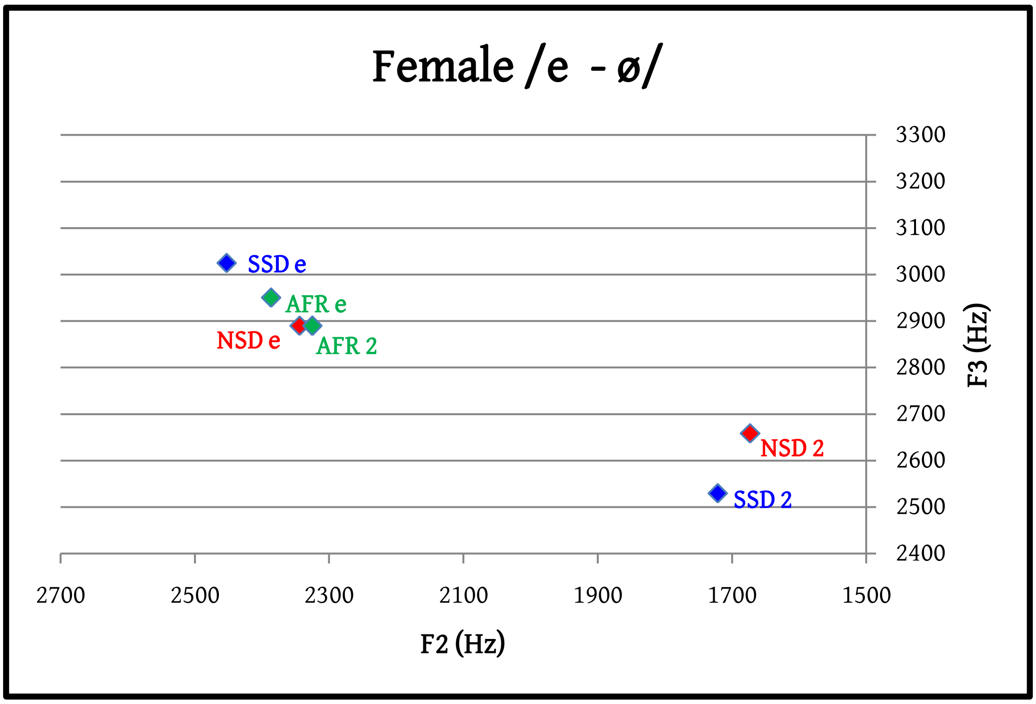
However, when the difference between /e/ and /ø/ within each variety separately is concerned, indications of a compensation of the merging of spectral features by increasing contrast for another feature (i.c. duration) become apparent. Table 5.6 reveals that the difference between Afrikaans /e/ and /ø/ is very significant, both for male and for female speakers. For both NSD and SSD speakers, the difference is less significant on the whole, a picture that also emerges from Figure 5.14 above.

Table 5.6. Welch t-test results for the difference in means of the duration of male and female /e/ and /ø/ for each of the three varieties.

Duration /e - ø/		
variety	**sex**	**Welch t-test result**
SSD	Male	t = -0.7284, df = 66.393, p-value = 0.469
	Female	t = -2.015, df = 70.824, p-value = 0.0477
NSD	Male	*t = -4.144, df = 73.177, p-value = <0.001*
	Female	t = -0.9701, df = 78, p-value = 0.335
Afrikaans	Male	*t = -2.6910, df = 77.815, p-value = 0.009*
	Female	*t = -3.6052, df = 77.729, p-value = <0.001*

Figures 5.15 and 5.16, which present the F2-F3 plane for /e – ø/, serve as another illustration of the merging and derounding in this vowel contrast in Afrikaans. In the male results, the F2 and F3 values of both vowels lie closer to one another than their Dutch counterparts; moreover, their absolute F2 and F3 values lie higher than those of their Dutch counterparts, indicating a greater degree of derounding. Although the F2 and F3 values of Afrikaans female /e/ are similar to those of its Dutch counterparts, the F2 and F3 values of Afrikaans female /ø/ are such that this vowel almost coincides with Afrikaans /e/, adding to the Afrikaans merging and derounding evidence. It goes without saying that these two Afrikaans vowels could maintain their phonemic distinctiveness with the use of a different diphthongal glide. This feature is not controlled for here, but this remark could be used as the basis for a future study.





Figures 5.15 and 5.16. F2-F3 plane with the average values of respectively male and female /e - ø/ in SSD, NSD and AFR.

5.2 Comparison with Adank, van Hout & Smits (2004)

This section attempts to provide a comparison of the results of the present study with those of Adank, van Hout & Smits (2004), in order to test the validity of the results obtained, and to assess whether the method of data collection used in the current study could prove helpful in future studies. Before a comparison can be made, certain differences between the two data sets have to be taken into account that arise from the manner in which the source material for the data sets was collected in both studies. Adank, van Hout & Smits (2004) made use of carrier sentences, in which the targeted vowels occurred in controlled consonantal contexts, leading to a formal experiment design. This was not the case for the present study, where (relatively) less formal, natural speech data was used. Since Adank, van Hout & Smits (2004) only offer lists of averages, and did not publish the results of individual vowel tokens, statistical comparison is not possible. However, a side-by-side comparison of averages can already serve as an incentive for further, more accurate investigation. When considering Tables 5.7 to 5.12 below, the following observations can be made: of the 96 features spread over six vowels (/ə/ was not taken into account in Adank, van Hout & Smits, 2004) measured in the present study, 63 (or roughly 66%) have values that lie within a 15% range of the values in Adank, van Hout & Smits 2004. Of these 63 values, 50 (52%) lie within a 10% range, and 33 (34%) lie within a 5% range. Without the necessary statistical calculations, these numbers do not provide any solid evidence, but it can nevertheless be argued that, everything considered, the feature values are in any case not vastly different.

In support of observations and transcriptions by Adank, van Hout & Smits (2004) and by van Leussen, Williams & Escudero (2011) (cf. also section 3.1.1), the difference in the F1 values between the contrasted vowels in the current data set seems minimal; this goes for all three vowel contrasts. This provides evidence for the claim that the vowels in these contrasts share the same height (cf. also Figure 1.1), and should, in future phonetic characterizations, be described accordingly.[26]

Certain differences between both data sets can be explained by keeping the natural speech character of the source material for this study in mind. Natural speech is produced faster than carrier sentences in a formal experiment design. When vowels are produced in a fast, natural context, along with other vowels, there is a greater need to maintain contrast and distinguish these vowels from the other vowels in the vowel space. It could be argued that the intrinsic vowel characteristics then become more apparent. Keeping these considerations in mind, the following predictions can be made for the vowels in the current study, which are situated roughly in the close to (close-)mid and front to central vowel space:

- For duration: faster speech will result in shorter vowel durations;
- For F1: a higher production of the close-mid to close vowels will result in lower F1 values;
- For F2: a more fronted production of the central to front vowels will result in higher F2 values;
- For F3: a more fronted production naturally entices a lesser degree of roundedness, which will result in higher F3 values.

Since only the more fronted, higher part of the vowel space is considered in the present study, and standard deviation results are lacking in Adank, van Heuven & Smits (2004), the concept of the Vowel Space Paradox (Van der Harst, 2011; cf. section 2.1.1) could not be studied here. However, given enough information on standard deviations in the former study and enough information on additional vowels in the

[26] However, more detailed analyses reveal F1 values that differ significantly, presumably caused by how the data are distributed around the relatively similar average values. See Appendices B and C.

latter one, there is no reason to suspect the Vowel Space Paradox could not be tested by comparing both data sets.

When testing the results from the current study against the above expectations, it becomes clear that a considerable majority of the measured vowel features conform to these expectations: of the 96 measured features, 79 (or 82%) behave as expected. Of course, other factors that are likely to influence the outcome of the results - like stress, intonation and consonantal environment - have not been taken into account. Furthermore, the present data set only included four speakers per sex per variety, and is thus prone to potential speaker-specific deviations and irregularities. A certain degree of caution is then absolutely needed when drawing conclusions on the basis of this limited comparison. However, the results at least point in the direction of a relatively high degree of validity of the method used in the current study.

Tables 5.7 and 5.8. Comparison of SSD and NSD male (M) and female (F) /i/ and /y/ duration, F1, F2 and F3 results from Adank, van Hout & Smits (2004) with the results obtained in the present study. Yellow-marked, orange-marked and red-marked values from the present study lie within a range of respectively 15%, 10% and 5% of the results of Adank *et al.* (2004). The second column reports if this value lies higher (↑) or lower (↓) than the corresponding value from Adank *et al.* (2004), and if marked green, this means that the result conforms to the predictions presented in the second paragraph of the present subsection. These table-reading guidelines also apply to Tables 5.9 to 5.12.

SSD		/i/			/y/		
		Adank et al.	Present study		Adank et al.	Present study	
Duration	M	96	80	↓	109	104	↓
	F	147	80	↓	153	109	↓
F1	M	278	236	↓	265	262	↓
	F	317	247	↓	337	254	↓
F2	M	2179	2245	↑	1825	1837	↑
	F	2647	2505	↓	2077	1953	↓
F3	M	2787	2878	↑	2348	2567	↑
	F	3312	3146	↓	2634	2558	↓

NSD		/i/			/y/		
		Adank et al.	Present study		Adank et al.	Present study	
Duration	M	94	78	↓	93	107	↑
	F	92	81	↓	96	105	↑
F1	M	278	228	↓	259	248	↓
	F	294	271	↓	305	267	↓
F2	M	2162	2332	↑	1734	1896	↑
	F	2524	2582	↑	1918	1901	↓
F3	M	2665	3060	↑	2205	2950	↑
	F	2911	3068	↑	2635	2653	↑

Tables 5.9 and 5.10. Comparison of SSD and NSD male (M) and female (F) /ɪ/ and /ʏ/ duration, F1, F2 and F3 results from Adank, van Hout & Smits (2004) with the results obtained in the present study.

SSD		/ɪ/			/ʏ/		
		Adank et al.	Present study		Adank et al.	Present study	
Duration	M	76	54	↓	77	64	↓
	F	88	50	↓	89	64	↓
F1	M	364	299	↓	353	336	↓
	F	455	312	↓	457	320	↓
F2	M	1745	1983	↑	1492	1568	↑
	F	2115	2269	↑	1785	1674	↓
F3	M	2566	2586	↑	2514	2574	↑
	F	2948	2948	=	2884	2598	↓

NSD		/ɪ/			/ʏ/		
		Adank et al.	Present study		Adank et al.	Present study	
Duration	M	82	52	↓	88	64	↓
	F	89	54	↓	89	67	↓
F1	M	361	317	↓	366	340	↓
	F	399	340	↓	417	350	↓
F2	M	1919	2068	↑	1595	1724	↑
	F	2276	2269	↓	1830	1659	↓
F3	M	2536	2655	↑	2345	2730	↑
	F	2883	2867	↓	2711	2734	↑

Table 5.11 and 5.12. Comparison of SSD and NSD male (M) and female (F) /e/ and /ø/ duration, F1, F2 and F3 results from Adank, van Hout & Smits (2004) and the present study.

SSD		/e/			/ø/		
		Adank et al.	Present study		Adank et al.	Present study	
Duration	M	169	105	↓	175	109	↓
	F	192	113	↓	200	123	↓
F1	M	386	341	↓	377	335	↓
	F	438	343	↓	437	332	↓
F2	M	1942	2075	↑	1534	1608	↑
	F	2349	2453	↑	1796	1721	↓
F3	M	2616	2658	↑	2422	2532	↑
	F	3007	3025	↑	2697	2529	↓

NSD		/e/			/ø/		
		Adank et al.	Present study		Adank et al.	Present study	
Duration	M	181	106	↓	184	123	↓
	F	177	113	↓	184	118	↓
F1	M	415	381	↓	407	389	↓
	F	452	384	↓	468	356	↓
F2	M	1887	2009	↑	1544	1770	↑
	F	2241	2344	↑	1726	1673	↓
F3	M	2545	2629	↑	2254	2595	↑
	F	2890	2890	=	2574	2658	↑

6 Conclusions and implications

In light of the recent increase in studies that have examined phonetic aspects of Dutch and Afrikaans, the main aim of the current study was to provide a first acoustic vowel description that included the two closely related language varieties of NSD and SSD, along with the Dutch daughter language of Afrikaans. Along with this descriptive aim, this study addressed two other aims, namely a comparative and a methodological one. This concluding section briefly discusses how these three aims were met in the present study, with specific attention to implications for future studies in varying linguistic subfields.

As for the descriptive aim, the results have been promising. Descriptions for the front rounded-unrounded vowel contrasts /i – y/, /ɪ - ʏ - ə/ and /e - ø/ were obtained which were in line with impressionistic observations and acoustic measurements made in previous studies covering a range of phenomena and features, particularly derounding and subsequent vowel merging in Afrikaans. For Afrikaans, more evidence of a merging tendency became apparent, especially for the /i - y/ vowel contrast, where vowel duration seems to remain the sole distinguishing feature. A comparison of the NSD and SSD results with the earlier descriptive study by Adank, van Hout & Smits (2004) revealed that the descriptions obtained in the present study are broadly reliable for Dutch. If this conclusion is extended to Afrikaans, the database designed in this study could serve as source material for future studies that want to address differences in the assessed vowels between Dutch and Afrikaans - given, of course, that the necessary caution is taken into consideration.

The comparative aspect of the current study has confirmed the few earlier comparisons of the three varieties. As expected, NSD and SSD differed to a very limited extent, and if they did differ, it was only in phonetic details. One of these details is a slight derounding tendency of NSD vowels in comparison with SSD vowels, which would support the claims by Stroop (1997) on Polder Dutch derounding and by Heeringa & de Wet (2008) on the Afrikaans pronunciation being closer to Northern than to Southern Dutch (varieties). It remains unclear whether this subtle phonetic difference will have an effect on Southern versus NSD results of Afrikaans vowel perception tasks. The manner in which Afrikaans differs from both Dutch varieties with regard to the examined vowels lies almost exclusively on the spectral level; on a durational level, Afrikaans is almost identical to Dutch. Derounding then seems to be the main factor contributing to the differences between Afrikaans and Dutch, with particularly the values for F2 and F3 differing significantly. The results from the present study bear some implications for future research; when accepting a near-complete merging of /y/ with /i/ in Afrikaans, research that deals with the perception of the Dutch contrast by Afrikaans listeners, and with the merged Afrikaans contrast by Dutch listeners, could reveal whether this phonetic merger also corresponds to a phonemic and perceptual reality.

The methodological purpose of the present study was to assess whether phonetic research could be conducted with a method of data collection not previously used in (Dutch) acoustic vowel research. A large database on the basis of spoken news reports (i.e. still relatively formal, yet natural speech) proved to be a relatively reliable source for vowel research, provided that the specific characteristics and irregularities of the speaking style were taken into consideration. The speaker sample for the present study was relatively limited; however, the standard language nature of the varieties under consideration, in combination with a considerable amount of productions per speaker, hopes to have added to the statistical validity of the current study.

It stands to reason that the design of the database, which does not take into consideration intonation, stress and consonantal context, still allows for a great deal of improvement. Furthermore, a database like the one used in the present study is less ideal for an in-depth, highly detailed analysis of the data. It then seems that the method proposed is more suitable for phonetic research that aims to provide a fairly superficial, but broad and comprehensive picture, rather than an in-depth, but narrow and limited one. Therefore, dialectometry, with its use of big data sets, could make use of acoustic measurements like the ones obtained in the current study to weigh the Levenshtein distances far more accurately than general IPA productions could ever hope to do. The methodology furthermore seems ideal for pilot studies that aim to acquire a rough outline, before going into detail with the use of more formal and controlled experiments. It is also a provisionary solution in those cases in which time or budget limitations prevent researchers from participant collection, especially when speaker selection within this new method can still be relatively controlled for, as was the case in the present study with its near-standard variety speaking news readers. The proposed methodology could also benefit the research of smaller languages or language varieties and dialects, most of which lack an extensive spoken corpus like the *Corpus Gesproken Nederlands* available to researchers of Dutch (varieties).

As a concluding remark, the current research hopes to have added new methodological insights to the fast-growing fields of Dutch and Afrikaans phonetic and linguistic vowel research, and hopes to encourage others to conduct studies in the gravely understudied research area that contrasts Afrikaans and Dutch on the phonetic and phonological level.

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University of Ghent

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Appendices

for

The close to close-mid front vowels of Northern Standard Dutch, Southern Standard Dutch and Afrikaans

A descriptive, comparative and methodological inquiry

Master thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in Advanced Studies in Linguistics: Linguistics in a Comparative Perspective

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Supervisor: prof. dr. Jacques Van Keymeulen

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Appendix A. Measurements results

This appendix presents the measurements of duration, F1, F2 and F3 for a total of 1680 vowel tokens. The data are grouped per variety and vowel, and averages and standard deviations are provided for the male and female results.

0 List of abbreviations used

№	number assigned to each speaker
M	male
F	female
Dur	duration
ms	milliseconds
F1	first formant
F2	second formant
F3	third formant
Hz	Hertz
Avg	average value
SD	standard deviation

1 Southern Standard Dutch

/i/											
№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
1	M	74	326	2067	2294	5	F	101	232	2634	3477
1	M	57	280	2036	2458	5	F	76	224	2567	3071
1	M	76	251	2273	2734	5	F	113	292	2642	3230
1	M	83	261	2512	3279	5	F	68	231	2551	3106
1	M	70	228	2431	3256	5	F	79	228	2381	2863
1	M	83	256	2209	2822	5	F	74	209	2458	2963
1	M	104	276	2346	3264	5	F	69	294	2444	2957
1	M	93	234	2373	2521	5	F	94	240	2563	3247
1	M	63	209	2287	2604	5	F	72	260	2606	3329
1	M	68	219	2226	2913	5	F	78	227	2572	2911
2	M	90	206	2342	3233	6	F	59	232	2432	2932
2	M	62	232	2214	2948	6	F	53	238	2582	3042
2	M	85	253	2233	2985	6	F	80	221	2588	3400
2	M	63	248	2254	3008	6	F	81	267	2664	3256
2	M	74	260	2296	3317	6	F	67	223	2546	3243
2	M	84	212	2290	2997	6	F	62	173	2328	3006
2	M	88	214	2217	2644	6	F	70	240	2677	3223
2	M	78	233	1968	2724	6	F	72	203	2678	3314
2	M	80	224	1925	2631	6	F	82	267	2694	3339
2	M	94	240	2444	3186	6	F	81	258	2630	3205
3	M	90	225	2279	2959	7	F	76	241	2353	3380
3	M	53	214	2096	2648	7	F	75	268	2361	2866
3	M	68	232	2246	2858	7	F	78	236	2549	3351
3	M	77	236	2418	2725	7	F	115	218	2546	3384
3	M	68	249	2161	2671	7	F	91	228	2518	3167
3	M	51	253	2013	2408	7	F	118	238	2523	3450
3	M	74	205	2184	2759	7	F	93	279	2459	3368
3	M	78	251	2016	2667	7	F	130	231	2381	3274
3	M	118	200	2218	3059	7	F	72	284	2484	3345
3	M	74	218	2155	2906	7	F	61	258	2513	3330
4	M	101	214	2295	2737	8	F	53	255	2058	2891
4	M	87	177	2409	3045	8	F	51	275	2260	2827
4	M	118	164	2386	3111	8	F	81	264	2617	3157
4	M	73	262	2481	3276	8	F	62	210	2356	2931
4	M	112	272	2186	2760	8	F	86	242	2513	2948
4	M	71	280	2090	2588	8	F	61	291	2318	2820
4	M	83	283	2324	3029	8	F	78	287	2369	2881
4	M	88	209	2507	3140	8	F	80	294	2597	3096
4	M	69	215	2363	3129	8	F	123	235	2571	3098
4	M	67	228	2013	2813	8	F	75	275	2616	3164
Avg		80	236	2245	2878	Avg		80	247	2505	3146
SD		16	31	152	266	SD		19	28	135	197

/y/											
№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
1	M	106	281	1661	2573	5	F	126	209	2107	2534
1	M	105	231	1951	2413	5	F	73	313	1842	2506
1	M	110	240	1547	2369	5	F	133	231	1932	2635
1	M	88	247	1907	2363	5	F	79	222	2130	2621
1	M	59	256	1673	2236	5	F	108	308	1916	2536
1	M	104	270	1818	2162	5	F	88	282	2038	2509
1	M	78	289	1597	2288	5	F	140	222	2042	2569
1	M	128	289	1729	2378	5	F	112	258	1906	2414
1	M	66	293	1703	2402	5	F	91	276	1994	2483
1	M	155	269	1855	2505	5	F	108	232	1931	2539
2	M	86	296	2053	3172	6	F	52	252	1748	2722
2	M	108	264	2223	2718	6	F	127	240	1740	2658
2	M	114	350	1743	2850	6	F	104	199	2021	2723
2	M	91,5	213	1909	2627	6	F	157	213	2131	2629
2	M	116	273	1649	2419	6	F	114	215	1884	2739
2	M	93	193	1878	2496	6	F	60	285	1787	2780
2	M	116	264	1865	2770	6	F	92	228	1979	2739
2	M	124	353	1455	2324	6	F	102	195	2267	2693
2	M	117	261	1692	2344	6	F	73	267	1898	2629
2	M	118	246	1750	2353	6	F	147	188	1882	2591
3	M	109	292	1724	2697	7	F	106	265	1784	2313
3	M	86	312	1634	2427	7	F	64	262	1643	2578
3	M	108	295	1813	2700	7	F	114	263	1801	2598
3	M	77	235	1782	2779	7	F	150	240	1958	2356
3	M	94	193	1728	2160	7	F	85	269	2079	2465
3	M	87	222	1783	2291	7	F	131	247	1999	2448
3	M	109	264	1794	2625	7	F	121	320	1865	2538
3	M	84	227	1826	2523	7	F	103	266	1993	2525
3	M	76	226	1945	2790	7	F	154	242	1986	2455
3	M	150	191	1867	2739	7	F	128	270	1918	1447
4	M	137	214	2160	2846	8	F	142	302	1825	2436
4	M	90	230	2106	2798	8	F	118	249	2038	2574
4	M	131	297	1784	2543	8	F	89	273	1926	2792
4	M	142	266	1952	2419	8	F	55	271	2039	2682
4	M	118	266	1899	2358	8	F	142	256	1923	2529
4	M	125	246	1687	2453	8	F	86	254	2221	2786
4	M	72	274	2221	2950	8	F	165	258	1909	2535
4	M	88	286	1793	2909	8	F	89	243	2131	2656
4	M	88	321	2263	3132	8	F	140	238	2045	2779
4	M	62	263	2078	2777	8	F	101	328	1873	2584
Avg		103	262	1837	2567	Avg		109	254	1953	2558
SD		24	38	187	252	SD		30	33	132	216

/ɪ/											
№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
1	M	57	342	1792	2352	5	F	56	316	2256	2934
1	M	51	297	2123	2516	5	F	51	423	2254	2896
1	M	66	332	2177	2469	5	F	47	268	2412	3037
1	M	35	266	2119	2553	5	F	59	249	2265	2970
1	M	41	256	2128	2462	5	F	41	359	2459	3039
1	M	50	343	1823	2463	5	F	49	321	2545	3169
1	M	56	293	1996	2608	5	F	53	289	2373	2854
1	M	58	203	2079	2559	5	F	40	285	2531	3057
1	M	65	294	2060	2600	5	F	58	266	2246	2766
1	M	50	298	2010	2543	5	F	59	297	2282	2968
2	M	63	352	2030	2629	6	F	52	278	2079	2792
2	M	52	339	2005	2539	6	F	48	417	2275	2896
2	M	43	248	2043	2904	6	F	50	359	2288	2867
2	M	50	278	1844	2678	6	F	45	289	2383	2973
2	M	45	305	1887	2616	6	F	38	329	2428	2830
2	M	59	281	1986	2597	6	F	55	405	2445	2994
2	M	49	347	1914	2534	6	F	51	288	2158	3029
2	M	66	340	2020	2644	6	F	42	300	2723	3116
2	M	58	354	1873	2541	6	F	45	302	2338	2913
2	M	48	264	1966	2454	6	F	62	341	2399	3042
3	M	46	313	1760	2498	7	F	54	344	2078	2849
3	M	45	384	1827	2379	7	F	50	292	2365	3099
3	M	57	306	1983	2562	7	F	46	244	2374	3128
3	M	47	303	2024	2495	7	F	46	237	2345	2979
3	M	51	298	1940	2549	7	F	54	346	2431	3032
3	M	52	338	1777	2490	7	F	52	333	2285	3079
3	M	53	351	1827	2413	7	F	47	289	2253	3082
3	M	59	331	1822	2406	7	F	46	228	2161	2679
3	M	53	325	1987	2579	7	F	59	301	2282	2839
3	M	52	363	1940	2448	7	F	47	249	2312	2892
4	M	65	235	1961	2725	8	F	58	330	2080	3016
4	M	48	279	1928	2666	8	F	64	355	2041	2874
4	M	71	261	2062	2755	8	F	57	338	2030	2748
4	M	63	234	2210	2742	8	F	53	308	1864	2900
4	M	71	241	2182	2747	8	F	45	307	2332	3007
4	M	54	260	1955	2850	8	F	52	296	2232	2966
4	M	43	316	1940	2678	8	F	48	292	1928	2892
4	M	58	292	2200	2780	8	F	40	341	2264	3026
4	M	63	226	2145	2808	8	F	51	375	1973	2843
4	M	46	271	1984	2595	8	F	43	286	1989	2796
Avg		54	299	1983	2586	Avg		50	312	2269	2947
SD		8	43	122	131	SD		6	46	180	115

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
1	M	57	379	1527	2248	5	F	72	294	1700	2434
1	M	48	343	1492	2407	5	F	75	328	1768	2479
1	M	65	339	1562	2311	5	F	80	284	1613	2422
1	M	66	339	1547	2387	5	F	78	311	1623	2551
1	M	58	256	1445	2593	5	F	66	307	1865	2645
1	M	62	334	1259	2250	5	F	52	275	1894	2762
1	M	52	352	1477	2195	5	F	59	290	1690	2627
1	M	62	363	1415	2314	5	F	68	286	1793	2468
1	M	55	359	1570	2729	5	F	69	269	1644	2554
1	M	74	274	1420	2355	5	F	61	361	1552	2777
2	M	59	275	1615	2389	6	F	59	343	1603	2678
2	M	80	223	1718	2632	6	F	53	283	1836	2609
2	M	72	335	1943	2796	6	F	69	305	1764	2471
2	M	62	314	1408	2488	6	F	49	297	1831	2716
2	M	57	310	1805	2774	6	F	59	293	1940	2575
2	M	69	350	1490	2704	6	F	57	253	1753	2527
2	M	58	362	1656	2606	6	F	72	296	1860	2531
2	M	58	382	1709	2976	6	F	66	367	1614	2754
2	M	58	345	1464	2522	6	F	62	263	1868	2832
2	M	58	366	1728	2867	6	F	70	219	1738	2560
3	M	68	429	1533	2785	7	F	67	278	1713	2458
3	M	69	426	1472	2844	7	F	76	322	1860	2542
3	M	69	384	1827	2670	7	F	65	315	1712	2500
3	M	78	406	1524	2205	7	F	59	336	1689	2603
3	M	61	309	1567	2476	7	F	68	277	1767	2443
3	M	63	340	1606	2846	7	F	69	400	1605	2600
3	M	85	383	1572	2164	7	F	65	354	1811	2469
3	M	72	379	1733	2861	7	F	77	413	1610	2521
3	M	64	276	1697	2353	7	F	74	380	1588	2628
3	M	73	264	1515	2378	7	F	51	299	1638	2665
4	M	56	249	1513	2783	8	F	53	306	1369	2429
4	M	70	302	1605	2568	8	F	62	302	1423	2644
4	M	65	294	1409	2735	8	F	63	454	1450	2653
4	M	60	351	1452	2715	8	F	55	305	1519	2757
4	M	58	377	1567	2738	8	F	41	357	1681	2749
4	M	53	355	1575	2476	8	F	64	364	1382	2623
4	M	60	337	1522	2523	8	F	68	383	1498	2784
4	M	58	301	1602	2779	8	F	63	331	1419	2449
4	M	61	325	1600	2862	8	F	56	332	1727	2725
4	M	76	360	1570	2656	8	F	56	358	1549	2695
Avg		64	336	1568	2574	Avg		64	320	1674	2598
SD		8	47	131	225	SD		9	47	149	117

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
1	M	59	481	1590	2490	5	F	41	353	1943	3099
1	M	60	358	1194	2353	5	F	38	424	1725	2955
1	M	57	464	1419	2594	5	F	60	310	1676	2884
1	M	62	320	1431	2644	5	F	65	346	1609	2963
1	M	43	311	1843	2390	5	F	53	326	1664	2645
1	M	60	299	1483	2262	5	F	47	299	1888	2997
1	M	43	364	1575	2474	5	F	48	265	1747	2789
1	M	49	241	2012	2063	5	F	54	382	1511	2835
1	M	42	266	1392	2714	5	F	56	282	1622	2904
1	M	39	361	1183	2511	5	F	44	395	1802	2977
2	M	45	427	1681	2948	6	F	56	331	1779	2903
2	M	70	431	1425	2506	6	F	45	378	1677	2909
2	M	71	360	1466	2923	6	F	44	404	1576	3072
2	M	52	285	1501	2874	6	F	60	440	1508	2918
2	M	63	197	1311	2693	6	F	82	316	1665	2741
2	M	69	291	1556	2689	6	F	59	289	1578	2757
2	M	70	346	1422	3075	6	F	48	388	1701	2891
2	M	51	305	1771	3093	6	F	53	312	1807	2876
2	M	48	383	1241	3090	6	F	51	223	1672	2643
2	M	50	265	1621	2889	6	F	51	335	1820	3016
3	M	52	340	1528	2429	7	F	47	409	1739	2681
3	M	61	367	1242	2528	7	F	45	291	1825	2772
3	M	49	314	1666	2637	7	F	50	326	1755	2842
3	M	69	376	1431	2234	7	F	45	325	1687	2735
3	M	52	255	1541	2620	7	F	53	322	1843	2719
3	M	43	365	1587	2377	7	F	58	279	1788	2538
3	M	49	406	1668	2373	7	F	68	401	1656	2647
3	M	78	393	1616	2537	7	F	69	368	1654	2751
3	M	60	371	1772	2633	7	F	64	389	1608	2757
3	M	42	336	1692	2176	7	F	45	450	1895	2859
4	M	54	274	1555	2713	8	F	54	360	1536	2991
4	M	67	358	1645	2488	8	F	55	468	1611	2895
4	M	56	231	2081	2529	8	F	58	314	1619	2843
4	M	65	337	1531	2622	8	F	68	425	1582	2885
4	M	61	247	1506	2824	8	F	53	401	1767	2947
4	M	56	225	1383	2733	8	F	56	311	1626	2844
4	M	55	360	1837	2693	8	F	63	443	1542	2935
4	M	57	325	1720	2740	8	F	52	353	1496	2775
4	M	44	379	1375	2491	8	F	59	293	1717	2859
4	M	43	347	1413	2483	8	F	51	346	1871	3024
Avg		55	334	1548	2603	Avg		54	352	1695	2852
SD		10	65	201	242	SD		9	57	116	127

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
1	M	116	321	2036	2372	5	F	113	406	2322	2966
1	M	100	345	1934	2371	5	F	98	436	2443	3046
1	M	91	314	1900	2331	5	F	105	457	2456	2927
1	M	109	329	2043	2581	5	F	130	321	2496	2951
1	M	79	372	2095	2589	5	F	95	409	2376	2936
1	M	104	277	2036	2901	5	F	105	317	2551	3156
1	M	87	324	1948	2339	5	F	136	249	2546	2992
1	M	97	331	1987	2579	5	F	116	442	2513	3059
1	M	112	294	2136	2789	5	F	114	395	2559	3018
1	M	99	337	2028	2739	5	F	115	336	2486	3039
2	M	111	355	2170	2609	6	F	153	316	2553	3095
2	M	149	338	2006	2758	6	F	147	265	2623	3104
2	M	104	352	1965	2537	6	F	118	249	2632	3156
2	M	83	357	2000	2602	6	F	119	365	2617	3118
2	M	99	356	2149	2878	6	F	109	282	2535	3111
2	M	86	361	2005	2769	6	F	112	327	2524	3084
2	M	94	330	1977	2714	6	F	104	265	2619	3024
2	M	82	324	2059	2695	6	F	128	278	2731	3066
2	M	107	351	2104	2660	6	F	113	299	2631	3150
2	M	115	354	1921	2614	6	F	124	287	2549	3022
3	M	100	415	1815	2485	7	F	114	416	2408	3191
3	M	95	314	2001	2475	7	F	88	313	2289	2937
3	M	104	273	2212	2854	7	F	88	399	2260	2909
3	M	119	310	2215	2697	7	F	143	399	2311	2968
3	M	105	325	2184	2618	7	F	103	401	2244	3130
3	M	107	295	2103	2662	7	F	91	384	2318	2929
3	M	111	366	2183	2737	7	F	106	419	2416	3038
3	M	95	384	2001	2563	7	F	120	368	2282	3035
3	M	81	341	2203	2565	7	F	117	362	2312	3067
3	M	70	363	1986	2550	7	F	86	338	2242	2944
4	M	122	370	1923	2836	8	F	105	319	2296	3127
4	M	125	321	2197	2743	8	F	90	329	2228	2803
4	M	115	267	2258	2849	8	F	101	296	2411	2874
4	M	110	258	2129	2729	8	F	125	326	2472	2931
4	M	109	445	2225	2766	8	F	142	361	2527	3088
4	M	121	403	2223	2895	8	F	133	276	2677	3190
4	M	135	331	2123	2716	8	F	116	334	2310	2984
4	M	104	358	2174	2809	8	F	102	315	2398	2964
4	M	127	400	2106	2713	8	F	95	337	2326	2810
4	M	133	392	2242	2651	8	F	120	336	2619	3065
Avg		105	341	1972	2608	Avg		113	343	2453	3025
SD		17	40	204	229	SD		17	56	139	97

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
1	M	98	319	1500	2174	5	F	130	243	1619	2441
1	M	79	345	1464	2182	5	F	109	373	1751	2537
1	M	94	372	1261	2137	5	F	129	389	1742	2350
1	M	101	327	1412	2211	5	F	89	392	1778	2608
1	M	117	314	1504	2208	5	F	113	345	1614	2392
1	M	107	369	1520	2222	5	F	126	315	1787	2519
1	M	104	360	1462	2387	5	F	138	351	1812	2397
1	M	169	322	1647	2504	5	F	92	416	1742	2579
1	M	80	334	1373	2149	5	F	109	366	1626	2465
1	M	109	342	1472	2180	5	F	117	298	1817	2555
2	M	112	310	1518	2351	6	F	91	239	1925	2588
2	M	91	404	2032	3146	6	F	145	297	1841	2529
2	M	122	251	1527	2570	6	F	155	295	1902	2578
2	M	148	218	1576	3076	6	F	148	301	1743	2631
2	M	117	335	1434	2412	6	F	109	328	1801	2553
2	M	113	316	1312	2869	6	F	135	314	1669	2474
2	M	84	373	1450	2633	6	F	120	318	1719	2718
2	M	79	315	1505	2601	6	F	162	318	1752	2436
2	M	119	383	1583	2707	6	F	160	315	1754	2607
2	M	69	354	1865	3322	6	F	112	277	1832	2527
3	M	125	357	1635	2421	7	F	156	374	1807	2420
3	M	113	363	1520	2179	7	F	90	346	1658	2550
3	M	102	337	1766	2768	7	F	145	296	1665	2655
3	M	101	432	1697	2758	7	F	130	335	1672	2560
3	M	85	348	1582	2233	7	F	142	392	1691	2416
3	M	79	326	1717	2600	7	F	70	343	1571	2565
3	M	95	264	1805	2370	7	F	152	380	1693	2457
3	M	63	365	1454	2004	7	F	97	350	1773	2674
3	M	112	331	1731	2047	7	F	128	419	1734	2519
3	M	107	386	1877	2793	7	F	134	329	1737	2446
4	M	151	299	1815	3155	8	F	118	287	1737	2437
4	M	98	269	1630	2856	8	F	91	346	1751	2522
4	M	175	312	1688	2580	8	F	96	338	1736	2463
4	M	164	312	2006	2692	8	F	135	297	1591	2609
4	M	123	373	1697	2486	8	F	154	281	1757	2547
4	M	111	329	1695	2765	8	F	97	352	1644	2454
4	M	103	338	1869	3051	8	F	131	354	1541	2607
4	M	87	374	1656	2463	8	F	104	335	1755	2435
4	M	132	374	1549	2653	8	F	133	303	1595	2621
4	M	115	236	1518	2350	8	F	113	325	1518	2755
Avg		109	335	1711	2582	Avg		123	332	1721	2530
SD		25	44	282	300	SD		23	42	92	93

2 Northern Standard Dutch

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
9	M	59	206	2277	2928	13	F	67	260	2643	3070
9	M	74	245	2453	3039	13	F	69	272	2682	3095
9	M	83	217	2458	2877	13	F	70	305	2761	3300
9	M	84	230	2359	2912	13	F	80	286	2831	3411
9	M	72	272	2380	2882	13	F	88	283	2835	3248
9	M	74	258	2276	2915	13	F	84	299	2636	3048
9	M	103	263	2377	3157	13	F	75	291	2517	3138
9	M	81	231	2204	2918	13	F	75	332	2531	3106
9	M	63	205	2321	3054	13	F	86	264	2820	3250
9	M	69	230	2441	3057	13	F	98	272	2786	3115
10	M	83	248	2534	3300	14	F	77	241	2536	3214
10	M	93	219	2540	3074	14	F	98	275	2654	3249
10	M	119	256	2444	3220	14	F	90	255	2651	3291
10	M	67	227	2493	3283	14	F	71	255	2666	3339
10	M	79	265	2589	3385	14	F	87	299	2645	3256
10	M	75	218	2279	3449	14	F	83	279	2683	3160
10	M	82	212	2384	3181	14	F	81	257	2679	3501
10	M	79	230	2384	2974	14	F	121	299	2713	3313
10	M	94	230	2424	3092	14	F	94	280	2729	3287
10	M	96	270	2247	2838	14	F	101	317	2633	3398
11	M	62	175	2278	3194	15	F	72	251	2201	3083
11	M	71	206	2314	3213	15	F	70	247	2479	2885
11	M	86	183	2445	3181	15	F	76	262	2436	3104
11	M	82	222	2307	2995	15	F	76	221	2251	2822
11	M	82	231	2328	3021	15	F	77	220	2518	2755
11	M	65	159	2322	3168	15	F	86	246	2279	2842
11	M	79	217	2226	3078	15	F	69	258	2439	2813
11	M	86	188	2353	3132	15	F	88	273	2625	2931
11	M	77	209	2294	2895	15	F	55	218	2344	2716
11	M	64	214	2386	3021	15	F	89	247	2659	3052
12	M	65	214	2176	3384	16	F	54	273	2306	2676
12	M	81	255	2359	2984	16	F	72	291	2622	2972
12	M	80	250	2296	3057	16	F	63	312	2555	2835
12	M	59	224	2195	3025	16	F	96	260	2516	3213
12	M	64	268	2194	3062	16	F	73	269	2469	2712
12	M	78	206	2351	2978	16	F	57	239	2489	2742
12	M	74	265	2266	2930	16	F	75	297	2580	2890
12	M	92	238	2268	3025	16	F	91	315	2465	3012
12	M	74	265	2028	2726	16	F	98	283	2641	2888
12	M	70	201	2047	2790	16	F	104	256	2776	2997
Avg		78	228	2332	3060	Avg		81	271	2582	3068
SD		12	28	120	164	SD		14	27	159	219

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
9	M	111	263	1948	3210	13	F	128	296	2049	2597
9	M	96	267	1833	3482	13	F	114	306	1997	2616
9	M	126	303	1834	3080	13	F	118	270	1985	2590
9	M	85	315	1743	3092	13	F	100	244	1899	2647
9	M	151	220	1979	3311	13	F	117	255	2053	2570
9	M	140	321	1899	3227	13	F	118	293	1973	2638
9	M	94	225	1872	2986	13	F	85	313	2130	2876
9	M	86	250	2180	3243	13	F	128	239	2017	2747
9	M	108	252	1873	3303	13	F	131	307	2007	2661
9	M	125	256	1904	3166	13	F	110	312	2028	2555
10	M	125	247	1791	2338	14	F	126	239	2105	2563
10	M	102	305	1856	2762	14	F	71	312	1875	2619
10	M	100	307	1787	2768	14	F	94	292	2078	2612
10	M	97	220	2043	2728	14	F	88	277	2114	2590
10	M	87	226	1975	2576	14	F	88	323	1900	2612
10	M	87	213	1896	2644	14	F	91	292	1993	2562
10	M	77	226	1642	2901	14	F	89	257	2005	2666
10	M	129	253	1956	2512	14	F	101	262	2102	2648
10	M	139	242	1726	2997	14	F	117	293	1691	2639
10	M	128	277	1994	2504	14	F	95	334	1583	2567
11	M	151	216	2011	3094	15	F	133	247	1879	2434
11	M	128	157	2022	2962	15	F	140	223	2197	2749
11	M	142	184	1893	2963	15	F	106	220	1762	2916
11	M	75	209	2006	2864	15	F	88	229	1640	2719
11	M	79	231	1950	3224	15	F	88	219	1889	2583
11	M	88	241	1830	2778	15	F	103	237	1983	2862
11	M	83	195	1995	3082	15	F	126	241	1830	2554
11	M	116	237	1896	3273	15	F	86	246	1670	2603
11	M	96	261	1926	2743	15	F	144	226	1688	2634
11	M	78	234	1777	3100	15	F	113	201	1828	2590
12	M	149	230	1791	3105	16	F	84	219	1791	2667
12	M	85	230	1887	3146	16	F	63	269	1920	2797
12	M	109	225	1954	2920	16	F	126	255	1994	2725
12	M	89	237	1893	2922	16	F	102	272	1914	2679
12	M	124	320	1973	2996	16	F	106	260	1646	2667
12	M	72	271	1748	2583	16	F	122	254	1726	2713
12	M	90	255	1807	3011	16	F	113	241	1672	2604
12	M	100	244	1976	2826	16	F	95	288	1751	2530
12	M	81	220	1889	2901	16	F	83	317	1817	2674
12	M	151	316	1868	2680	16	F	73	318	1872	2846
Avg		107	247	1896	2950	Avg		105	267	1901	2653
SD		25	38	103	258	SD		20	35	158	101

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
9	M	41	388	1878	2837	13	F	59	346	2437	2812
9	M	47	340	2122	2590	13	F	69	315	2213	2714
9	M	54	223	2208	2660	13	F	57	363	2537	3069
9	M	38	373	1925	2666	13	F	44	348	2373	2880
9	M	36	310	1922	2566	13	F	46	390	2490	2906
9	M	40	365	2050	2664	13	F	41	284	2238	2885
9	M	52	349	2126	2604	13	F	41	308	2254	2740
9	M	49	358	2066	2709	13	F	63	405	2126	2659
9	M	41	410	2153	2672	13	F	68	359	2147	2712
9	M	71	349	2263	2865	13	F	51	390	2239	2854
10	M	56	327	1997	2657	14	F	58	300	2614	3058
10	M	43	304	2284	2778	14	F	43	292	2560	3054
10	M	56	325	2223	2681	14	F	48	354	2215	2765
10	M	50	398	1844	2907	14	F	59	352	2420	2848
10	M	49	327	2097	2591	14	F	57	366	2275	2829
10	M	64	357	1967	2639	14	F	46	328	2476	2838
10	M	47	317	2207	2792	14	F	60	246	2721	3088
10	M	58	285	2009	2468	14	F	63	411	2314	2854
10	M	59	280	2207	2573	14	F	44	375	2279	2782
10	M	59	310	1936	2553	14	F	53	352	2299	3036
11	M	65	292	2000	2468	15	F	62	314	2027	2971
11	M	58	285	2166	2621	15	F	45	346	2088	2834
11	M	50	329	2101	2752	15	F	54	300	2154	3048
11	M	66	328	2143	2705	15	F	55	330	2086	2920
11	M	52	307	2059	2644	15	F	56	338	1977	2862
11	M	62	264	2088	2762	15	F	58	311	2183	2920
11	M	56	305	2212	2710	15	F	56	282	2031	2785
11	M	46	303	2102	2803	15	F	57	297	2003	2788
11	M	61	269	2162	2831	15	F	57	315	2036	2872
11	M	51	273	2145	2797	15	F	56	328	2206	2794
12	M	40	257	2249	2920	16	F	61	376	2548	3013
12	M	50	303	1969	2595	16	F	46	414	2294	2904
12	M	58	312	1788	2354	16	F	52	321	2065	2730
12	M	52	343	2111	2496	16	F	55	316	2474	2889
12	M	52	328	2005	2498	16	F	49	336	2239	2703
12	M	44	319	1955	2568	16	F	72	323	2355	2712
12	M	47	341	1972	2430	16	F	44	325	2431	2924
12	M	65	250	1972	2588	16	F	43	381	1951	2852
12	M	58	280	1977	2474	16	F	61	374	2163	2773
12	M	54	304	2065	2705	16	F	52	391	2240	3013
Avg		52	317	2068	2655	Avg		54	340	2269	2867
SD		8	40	121	134	SD		8	39	190	115

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)		№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
9	M	59	409	1488	2404		13	F	59	343	1662	3080
9	M	65	413	1577	2651		13	F	74	257	1482	2838
9	M	62	338	1449	2653		13	F	80	475	1728	2524
9	M	48	319	1621	2855		13	F	74	270	1674	2547
9	M	64	365	1807	3055		13	F	73	411	1693	2613
9	M	58	394	1578	2745		13	F	66	381	1720	2940
9	M	65	367	1678	2974		13	F	67	369	1692	2925
9	M	58	352	1616	2729		13	F	62	228	1766	2699
9	M	69	407	1584	2883		13	F	54	440	1562	2671
9	M	69	395	1652	3025		13	F	54	399	1428	2772
10	M	72	273	1992	3103		14	F	54	333	1646	2628
10	M	84	332	1234	2863		14	F	85	335	2026	2642
10	M	77	372	1934	2850		14	F	70	391	1668	2827
10	M	52	289	1812	2901		14	F	66	317	1581	2794
10	M	58	277	1712	2509		14	F	61	263	1538	2825
10	M	57	286	1611	2600		14	F	102	363	1810	2589
10	M	66	337	1579	2598		14	F	86	312	1517	2888
10	M	62	372	1608	2451		14	F	40	307	1778	2797
10	M	52	385	1559	2799		14	F	45	243	1462	2685
10	M	72	347	1591	2582		14	F	54	384	1818	2816
11	M	54	304	1461	2939		15	F	61	337	1599	2868
11	M	58	307	1844	2908		15	F	61	342	1924	2977
11	M	52	302	1690	2965		15	F	46	271	1593	2852
11	M	74	342	1693	2602		15	F	69	378	1528	2930
11	M	66	269	2170	3002		15	F	102	315	1931	2547
11	M	61	528	2273	2802		15	F	55	325	1458	2984
11	M	66	335	1808	2775		15	F	79	417	1848	2800
11	M	60	277	1813	3063		15	F	71	333	1746	2987
11	M	96	273	2109	3043		15	F	76	413	1602	2501
11	M	53	406	2115	3074		15	F	75	321	1458	2488
12	M	62	233	1840	2467		16	F	62	363	1714	2588
12	M	72	291	1792	2274		16	F	66	272	1653	2733
12	M	71	325	1560	2504		16	F	82	331	1667	2625
12	M	81	329	1764	2226		16	F	54	413	1525	2481
12	M	60	354	1503	2591		16	F	58	434	1543	2662
12	M	51	208	1743	2555		16	F	63	345	1554	2581
12	M	64	340	1738	2646		16	F	64	453	1714	2655
12	M	56	307	1808	2592		16	F	75	360	1625	2549
12	M	75	480	1924	2852		16	F	67	367	1584	2563
12	M	68	355	1647	2090		16	F	50	379	1847	2899
Avg		64	340	1724	2730		Avg		67	350	1659	2734
SD		10	62	211	250		SD		14	59	141	163

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
9	M	50	398	1445	2612	13	F	50	384	1897	2778
9	M	52	557	1497	2485	13	F	40	264	1469	3122
9	M	42	334	1704	2814	13	F	48	298	1961	2797
9	M	55	365	1500	2732	13	F	58	409	1923	2779
9	M	41	447	1800	2473	13	F	40	517	1749	2915
9	M	49	411	1507	2580	13	F	41	321	1439	3238
9	M	45	415	1629	2766	13	F	79	335	1694	2805
9	M	50	373	1561	2706	13	F	45	294	1658	2707
9	M	46	403	1624	2456	13	F	52	370	1518	2824
9	M	55	527	1682	2631	13	F	41	383	1412	3021
10	M	69	343	1824	2555	14	F	44	349	1533	2854
10	M	59	247	1690	2871	14	F	55	342	1767	2830
10	M	58	210	1803	2485	14	F	57	417	1712	2607
10	M	43	215	1590	2858	14	F	61	396	1571	2883
10	M	59	332	1573	2639	14	F	56	256	1483	3118
10	M	45	230	1646	2747	14	F	43	332	2001	3076
10	M	46	300	1494	2792	14	F	65	234	1757	3122
10	M	46	272	1441	2842	14	F	64	272	1904	2958
10	M	65	363	1716	2622	14	F	60	370	1630	2895
10	M	47	270	1868	2932	14	F	40	227	1656	3075
11	M	62	215	2267	3382	15	F	60	398	1633	2775
11	M	58	596	2226	3394	15	F	50	341	1496	2834
11	M	65	292	2147	3386	15	F	46	288	1273	3087
11	M	43	316	1911	2940	15	F	34	325	1826	2850
11	M	44	283	1889	3058	15	F	68	305	1713	2909
11	M	53	448	1492	2483	15	F	46	276	1717	2653
11	M	43	317	1368	2939	15	F	42	334	1757	2884
11	M	48	351	1680	2603	15	F	45	305	1412	3051
11	M	58	366	1735	2259	15	F	64	382	1748	3028
11	M	61	357	1680	2679	15	F	60	381	1801	2959
12	M	57	337	1480	2345	16	F	42	363	1796	2788
12	M	60	479	1987	3176	16	F	65	485	1776	2916
12	M	54	234	1614	2613	16	F	78	454	1751	2766
12	M	53	279	1409	2583	16	F	66	387	1632	2966
12	M	57	289	1404	2502	16	F	62	356	1645	2925
12	M	55	447	1672	2624	16	F	53	348	1612	2546
12	M	72	327	1620	2784	16	F	50	373	1596	2696
12	M	61	244	1421	2622	16	F	55	468	1587	2713
12	M	42	331	1461	2569	16	F	60	382	1744	2748
12	M	48	380	1558	2644	16	F	48	340	1632	2699
Avg		53	348	1665	2730	Avg		53	352	1672	2880
SD		8	98	219	265	SD		11	65	161	158

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)		№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
9	M	105	412	1981	2812		13	F	104	433	2264	3028
9	M	80	346	1870	2552		13	F	126	435	2279	2877
9	M	111	422	1984	2592		13	F	127	430	2204	2837
9	M	131	458	2087	2610		13	F	109	365	2409	2762
9	M	101	464	2048	2701		13	F	134	345	2538	3078
9	M	81	433	1935	2454		13	F	104	308	2497	2810
9	M	95	416	2227	2832		13	F	127	449	2367	2884
9	M	89	409	2169	2689		13	F	96	454	1949	2743
9	M	117	499	2053	2676		13	F	125	324	2553	2915
9	M	65	489	1947	2516		13	F	135	331	2536	2976
10	M	135	387	1988	2682		14	F	96	461	2283	2984
10	M	131	350	2045	2553		14	F	127	392	2435	2946
10	M	63	310	2173	2667		14	F	146	227	2530	2867
10	M	154	348	2022	2530		14	F	132	346	2342	2688
10	M	144	336	2130	2749		14	F	104	388	2300	2934
10	M	124	370	1965	2593		14	F	149	369	2271	2949
10	M	125	402	1998	2550		14	F	154	332	2514	3146
10	M	89	398	2028	2874		14	F	91	320	2286	2918
10	M	79	336	1994	2789		14	F	111	387	2317	2883
10	M	118	441	1944	2636		14	F	115	304	2509	2926
11	M	101	383	2030	2619		15	F	102	428	2238	2803
11	M	81	347	2076	2547		15	F	115	288	2395	2882
11	M	107	362	2001	2775		15	F	106	434	2110	2740
11	M	123	378	2000	2579		15	F	126	433	2256	2819
11	M	125	378	1908	2509		15	F	145	360	2312	2824
11	M	108	406	1961	2428		15	F	127	295	2361	2932
11	M	100	412	1870	2453		15	F	80	415	2023	3046
11	M	103	419	1991	2649		15	F	73	339	2363	2666
11	M	112	296	2160	2708		15	F	110	441	2182	2887
11	M	98	376	1952	2605		15	F	121	365	2265	2974
12	M	96	411	1879	2456		16	F	132	463	2419	3006
12	M	97	274	2084	2633		16	F	108	283	2462	2840
12	M	78	373	1972	2507		16	F	69	370	2569	2829
12	M	131	291	1899	2535		16	F	85	495	2563	3028
12	M	110	404	1880	2627		16	F	106	372	2293	2826
12	M	108	264	2112	2878		16	F	94	341	2536	3014
12	M	122	370	1951	2498		16	F	112	506	2150	2793
12	M	98	405	1877	2637		16	F	115	497	2324	2842
12	M	96	275	2186	2856		16	F	91	380	2238	2905
12	M	102	381	1985	2611		16	F	102	414	2318	2796
Avg		106	381	2009	2629		Avg		113	383	2344	2890
SD		21	56	94	121		SD		20	65	149	106

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
9	M	137	490	1676	2539	13	F	97	396	1795	2721
9	M	119	390	1828	2633	13	F	124	340	1743	2665
9	M	115	232	1618	2650	13	F	131	373	1724	2502
9	M	143	330	1701	2367	13	F	100	388	1859	2555
9	M	109	333	1919	2412	13	F	99	432	1694	2728
9	M	92	340	1899	2510	13	F	117	425	1504	2597
9	M	134	328	1963	2551	13	F	114	301	1973	2604
9	M	144	303	1530	2253	13	F	115	387	1798	2650
9	M	127	378	2081	2987	13	F	118	349	1674	2504
9	M	134	497	1872	2407	13	F	129	402	1761	2826
10	M	104	319	1714	2462	14	F	163	428	1579	2672
10	M	100	350	1577	2692	14	F	131	348	1702	2567
10	M	130	416	1498	2509	14	F	100	479	1708	2734
10	M	144	256	1644	2810	14	F	121	346	1872	2455
10	M	92	360	1335	2468	14	F	131	381	1671	2719
10	M	124	357	1561	2742	14	F	102	395	1610	2894
10	M	111	291	1606	2535	14	F	135	432	1683	2690
10	M	96	280	1818	2367	14	F	151	353	1786	2736
10	M	140	386	1476	2735	14	F	156	306	1783	2723
10	M	114	340	1624	2572	14	F	140	325	1715	2643
11	M	124	387	1614	2422	15	F	140	317	1728	2825
11	M	139	300	1960	3075	15	F	123	323	1838	2722
11	M	130	437	2031	3014	15	F	105	323	1659	2701
11	M	116	328	1572	2848	15	F	110	393	1785	2687
11	M	135	472	1747	2406	15	F	96	313	1881	2706
11	M	116	462	1710	2307	15	F	81	367	1651	2758
11	M	138	315	1717	2281	15	F	108	377	1676	2705
11	M	119	330	1915	2889	15	F	103	403	1453	2479
11	M	87	286	2069	2737	15	F	151	286	1740	2731
11	M	106	486	2047	3112	15	F	124	353	1497	2625
12	M	121	1051	2006	3124	16	F	114	298	1398	2677
12	M	129	303	1786	2413	16	F	93	338	1498	2713
12	M	146	971	2241	2881	16	F	90	347	1590	2537
12	M	140	300	1853	2451	16	F	99	318	1684	2566
12	M	123	308	1763	2372	16	F	120	336	1658	2423
12	M	135	580	1959	3039	16	F	100	299	1426	2675
12	M	117	254	1924	2576	16	F	81	274	1458	2683
12	M	136	285	1693	2264	16	F	119	353	1519	2672
12	M	117	427	1610	2184	16	F	139	300	1736	2648
12	M	132	319	1638	2203	16	F	137	336	1412	2614
Avg		123	164	1770	2595	Avg		118	356	1673	2658
SD		16	389	198	267	SD		20	47	140	101

3 Afrikaans

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
17	M	84	225	2275	2902	21	F	47	318	2528	3028
17	M	77	181	2349	2764	21	F	79	294	2348	3047
17	M	85	213	2208	2861	21	F	61	283	2230	2919
17	M	56	231	2102	2688	21	F	55	258	2386	3120
17	M	83	197	2260	2977	21	F	63	212	2487	2949
17	M	50	167	2450	2860	21	F	47	253	2537	3283
17	M	80	220	2368	3009	21	F	98	270	2678	3165
17	M	93	177	2472	2995	21	F	75	252	2552	3052
17	M	93	147	2583	3068	21	F	73	270	2462	2811
17	M	79	242	2395	2915	21	F	93	225	2645	3292
18	M	71	184	2206	3004	22	F	82	252	2442	2965
18	M	78	272	2286	2952	22	F	70	240	2582	3105
18	M	80	261	2277	3170	22	F	90	255	2645	3109
18	M	56	213	2156	2931	22	F	64	278	2679	2957
18	M	67	182	2197	3141	22	F	105	220	2557	2952
18	M	64	205	2142	3003	22	F	53	383	2432	3129
18	M	72	304	2253	2922	22	F	62	205	2558	3131
18	M	82	248	2232	3029	22	F	47	265	2515	3126
18	M	63	246	2147	2856	22	F	66	297	2442	2875
18	M	60	300	2221	2783	22	F	64	313	2562	2963
19	M	73	233	2304	2898	23	F	71	286	2387	2862
19	M	71	229	2242	2869	23	F	80	295	2458	2970
19	M	42	292	2358	3094	23	F	52	267	2304	2801
19	M	77	259	2339	3024	23	F	71	292	2150	2781
19	M	74	235	2185	2864	23	F	53	286	2142	2762
19	M	87	233	2435	2842	23	F	58	265	2207	2829
19	M	76	258	2334	2867	23	F	65	322	2355	2747
19	M	78	238	2376	2977	23	F	55	293	2305	2969
19	M	62	261	2313	2799	23	F	104	266	2359	2739
19	M	59	294	2092	2494	23	F	74	265	2393	2744
20	M	61	270	2144	2900	24	F	65	310	2317	2865
20	M	85	317	2396	3251	24	F	86	249	2525	2921
20	M	58	269	2148	2861	24	F	55	229	2459	2934
20	M	58	248	2189	2879	24	F	89	281	2547	3031
20	M	75	229	2256	2999	24	F	63	309	2289	2789
20	M	89	260	2317	2846	24	F	55	265	2329	2757
20	M	70	228	2258	2789	24	F	51	242	2542	3038
20	M	80	236	2170	2917	24	F	73	295	2767	3238
20	M	74	235	2232	2712	24	F	62	291	2522	2809
20	M	105	193	2272	2827	24	F	80	303	2912	3363
Avg		73	236	2273	2913	Avg		69	274	2463	2973
SD		13	39	108	137	SD		16	34	163	166

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)		№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
17	M	59	210	2164	2752		21	F	100	260	2195	2945
17	M	55	131	2225	2853		21	F	47	278	2360	2938
17	M	119	203	2275	2635		21	F	78	273	2345	3060
17	M	90	211	2391	3005		21	F	53	250	2552	3171
17	M	94	158	2295	2949		21	F	102	266	2579	2765
17	M	142	176	2498	3130		21	F	99	219	2389	2760
17	M	94	188	2507	2847		21	F	91	241	2405	2752
17	M	90	195	2319	2803		21	F	116	275	2568	2779
17	M	111	185	2362	2869		21	F	78	173	2292	2843
17	M	94	195	2453	2768		21	F	109	244	2589	3097
18	M	141	190	2212	2922		22	F	147	215	2608	3246
18	M	103	212	2301	2956		22	F	126	215	2909	3106
18	M	149	229	2240	2947		22	F	75	273	2583	3026
18	M	146	254	2234	2994		22	F	128	192	2919	3161
18	M	45	174	2297	2949		22	F	63	307	2455	3045
18	M	97	209	2200	2918		22	F	46	289	2628	2928
18	M	97	261	2434	3056		22	F	123	303	2634	3082
18	M	157	250	2219	2979		22	F	67	286	2574	2986
18	M	88	325	2295	2811		22	F	88	219	2684	3072
18	M	71	216	2252	3022		22	F	93	264	2626	2930
19	M	113	247	2369	3084		23	F	78	302	2142	2722
19	M	118	207	2408	3166		23	F	113	303	2475	2831
19	M	39	258	2214	2790		23	F	68	282	2548	2855
19	M	117	286	2131	2626		23	F	110	267	2238	2841
19	M	170	206	2435	3297		23	F	74	272	2367	2918
19	M	142	175	2483	3212		23	F	64	298	2256	2814
19	M	131	207	2777	3254		23	F	85	209	2425	2756
19	M	81	294	2058	2528		23	F	87	316	2230	2772
19	M	135	225	2462	3274		23	F	72	337	1931	2647
19	M	116	238	2468	3144		23	F	73	317	2154	2740
20	M	113	260	2173	2673		24	F	77	265	2345	2694
20	M	127	221	2294	2860		24	F	112	304	2380	2789
20	M	122	214	2184	3081		24	F	85	333	2249	2654
20	M	60	254	2214	2627		24	F	113	320	2366	2758
20	M	122	194	2118	2669		24	F	95	254	2368	2997
20	M	63	248	2448	2618		24	F	131	315	2585	2983
20	M	57	213	2324	2662		24	F	118	226	2577	2942
20	M	139	220	2265	2927		24	F	118	231	2516	2914
20	M	94	278	2240	2937		24	F	95	275	2686	2945
20	M	61	228	2273	2937		24	F	103	281	2437	2843
Avg		104	221	2313	2913		Avg		93	269	2454	2903
SD		33	39	137	197		SD		24	40	201	151

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)		№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
17	M	40	1550	2623	3582		21	F	65	395	1805	2731
17	M	62	1507	2946	3401		21	F	37	508	1846	2709
17	M	70	1606	2864	3738		21	F	66	394	1979	2792
17	M	54	1400	2561	3234		21	F	52	465	1851	2893
17	M	50	1577	2663	3527		21	F	41	369	1754	2824
17	M	57	1548	2680	3567		21	F	41	343	1819	2904
17	M	54	1513	2575	3369		21	F	51	330	1955	3070
17	M	51	1453	2601	3459		21	F	65	408	1691	2753
17	M	64	1651	2596	3854		21	F	54	324	1724	3156
17	M	54	1668	2731	3926		21	F	43	325	1879	3034
18	M	35	430	1754	2652		22	F	52	353	1889	2874
18	M	57	412	1818	2717		22	F	53	343	1830	3039
18	M	34	449	1770	2653		22	F	51	262	2059	3041
18	M	42	414	1731	2568		22	F	55	414	2062	2973
18	M	39	363	1758	2804		22	F	59	252	2097	3014
18	M	43	477	1709	2882		22	F	48	412	1844	3007
18	M	48	451	1657	2824		22	F	53	356	1830	2930
18	M	48	529	1255	2799		22	F	54	283	1879	2917
18	M	46	483	1331	2867		22	F	57	269	1810	2900
18	M	50	474	1316	2719		22	F	60	508	1811	2992
19	M	58	441	1773	2840		23	F	53	444	1650	2438
19	M	46	476	1746	2883		23	F	48	413	1653	2781
19	M	53	373	1870	2719		23	F	43	345	1645	2672
19	M	58	1647	2756	3874		23	F	52	423	1721	3062
19	M	50	373	1515	3128		23	F	52	341	1682	2610
19	M	52	845	2513	3457		23	F	42	323	1467	3032
19	M	46	460	1471	2745		23	F	62	490	1805	2617
19	M	50	1266	2747	3652		23	F	42	346	1686	2974
19	M	46	458	2098	3361		23	F	51	287	1578	2760
19	M	51	430	1745	2946		23	F	51	322	1618	2949
20	M	47	489	1490	2508		24	F	50	298	1738	2845
20	M	46	476	1587	2466		24	F	54	441	2088	2895
20	M	53	431	1560	2326		24	F	52	326	1894	2903
20	M	48	475	1466	2492		24	F	53	292	1999	2871
20	M	50	339	1703	3029		24	F	43	335	2050	2850
20	M	40	400	1701	2347		24	F	40	325	1996	2807
20	M	57	342	1947	2341		24	F	56	456	1804	2903
20	M	41	532	1809	3307		24	F	55	254	2072	2813
20	M	45	363	1357	2905		24	F	51	381	2072	2741
20	M	49	414	1649	2774		24	F	61	371	1869	2723
Avg		50	775	1986	3031		Avg		52	363	1838	2870
SD		8	512	520	462		SD		7	69	157	148

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
17	M	52	1395	2760	3158	21	F	50	234	1288	2712
17	M	66	1344	2594	3191	21	F	41	370	1435	2741
17	M	60	1571	2713	3464	21	F	69	380	1378	2758
17	M	64	1242	2616	3416	21	F	53	329	1598	2829
17	M	59	1634	2892	3616	21	F	51	364	1819	2933
17	M	73	1326	2161	3149	21	F	53	330	1373	2563
17	M	57	1231	2420	3040	21	F	62	427	1627	2570
17	M	60	1275	2430	3354	21	F	57	335	1699	2719
17	M	69	1354	2534	3314	21	F	68	381	1790	2885
17	M	54	1420	2624	3375	21	F	73	364	1514	2841
18	M	59	316	1692	2602	22	F	55	444	1666	2834
18	M	60	526	1828	2716	22	F	60	344	1406	3006
18	M	62	420	1706	2712	22	F	59	357	1696	2762
18	M	54	577	1287	2856	22	F	62	288	1626	2710
18	M	73	420	1733	2699	22	F	64	259	1561	2996
18	M	57	481	1725	2884	22	F	58	237	1600	2763
18	M	66	428	1946	2746	22	F	68	316	1740	2772
18	M	56	427	1764	2899	22	F	63	380	1366	2716
18	M	54	272	1727	2675	22	F	63	426	1566	2880
18	M	66	319	1858	2631	22	F	54	345	1528	2799
19	M	56	399	1563	2784	23	F	66	333	1715	2657
19	M	49	435	1799	2721	23	F	53	300	1525	2823
19	M	50	433	1732	2594	23	F	67	383	1500	2610
19	M	58	373	1882	2894	23	F	67	420	1676	3104
19	M	46	347	1673	2611	23	F	77	445	1554	3022
19	M	63	465	1523	2702	23	F	56	380	1689	3032
19	M	46	464	1688	2635	23	F	48	391	1505	2793
19	M	35	372	1688	2716	23	F	54	332	1620	3003
19	M	41	376	1806	2722	23	F	79	384	1678	2729
19	M	65	381	1775	2558	23	F	97	430	1590	2864
20	M	65	436	1579	2216	24	F	74	473	1692	2823
20	M	60	352	1546	2776	24	F	49	337	1947	2783
20	M	51	337	1597	2468	24	F	70	477	1781	2811
20	M	68	485	1687	2339	24	F	65	306	1586	2598
20	M	54	371	1547	2540	24	F	59	401	1639	2722
20	M	51	354	1648	2575	24	F	69	347	1485	2663
20	M	56	360	1762	2700	24	F	64	291	1619	2717
20	M	53	468	1829	2705	24	F	74	334	1957	2819
20	M	66	355	1636	2580	24	F	67	509	1910	2936
20	M	66	400	1549	2471	24	F	71	300	1875	2924
Avg		58	649	1913	2820	Avg		63	362	1620	2806
SD		8	436	415	325	SD		10	63	159	131

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
17	M	42	1295	2615	3180	21	F	44	292	1805	2857
17	M	58	1523	2759	3357	21	F	75	253	1750	2695
17	M	49	1628	2674	3705	21	F	59	389	1629	2764
17	M	62	1465	2749	3486	21	F	56	370	1922	2751
17	M	59	1515	2614	3494	21	F	38	249	1863	2995
17	M	49	1576	2737	3546	21	F	57	260	1648	2521
17	M	64	1464	2589	3279	21	F	49	245	1438	2859
17	M	67	1519	2783	3617	21	F	44	253	1123	2923
17	M	47	1639	2827	3534	21	F	52	419	1804	2796
17	M	67	1529	2947	3685	21	F	51	330	1711	2800
18	M	42	381	1840	3133	22	F	52	338	2078	2942
18	M	80	972	2666	3520	22	F	36	380	1757	2966
18	M	52	423	1802	2622	22	F	55	437	1619	2944
18	M	67	438	1834	2624	22	F	45	430	1899	2933
18	M	69	510	1578	2794	22	F	68	247	1533	2977
18	M	50	899	2621	3538	22	F	35	312	1369	2890
18	M	61	380	1855	2524	22	F	54	274	1858	2825
18	M	61	444	1873	2659	22	F	42	375	1912	2988
18	M	42	300	2064	2731	22	F	66	337	1653	2840
18	M	48	270	1791	2627	22	F	32	288	1950	2894
19	M	64	497	1663	2549	23	F	59	347	1595	2744
19	M	50	469	1622	2788	23	F	39	492	1611	2757
19	M	43	364	1536	2577	23	F	67	412	1533	2884
19	M	52	457	1646	2567	23	F	57	455	1758	2748
19	M	46	390	1133	2433	23	F	74	340	1574	2991
19	M	48	375	1685	2638	23	F	52	563	1598	2714
19	M	45	347	1839	2511	23	F	45	308	1566	2979
19	M	43	415	1535	2459	23	F	46	382	1641	2816
19	M	47	348	1538	2827	23	F	59	343	1619	2769
19	M	64	508	1654	2473	23	F	45	416	1699	2787
20	M	46	342	1452	2614	24	F	43	384	1815	2821
20	M	44	321	1508	2857	24	F	46	220	1837	2896
20	M	62	402	1533	2419	24	F	58	336	1940	2813
20	M	47	488	1564	2447	24	F	46	327	1775	2730
20	M	47	390	1617	2433	24	F	44	376	2047	2851
20	M	37	361	1841	2713	24	F	55	327	1704	2644
20	M	51	389	1638	2510	24	F	43	216	1678	2751
20	M	61	296	1453	2331	24	F	42	314	1793	2883
20	M	50	374	1376	2478	24	F	46	367	1646	2875
20	M	54	366	1408	2378	24	F	56	383	1968	2869
Avg		53	702	1961	2866	Avg		51	345	1718	2837
SD		10	495	528	449	SD		10	76	187	104

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№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
17	M	104	247	2470	2930	21	F	133	296	2282	2797
17	M	98	243	2150	2961	21	F	85	292	2068	2811
17	M	97	266	2251	2680	21	F	73	334	2328	2913
17	M	96	247	2170	2980	21	F	137	311	2293	3004
17	M	72	239	2328	2928	21	F	110	300	2400	2694
17	M	93	243	2346	2852	21	F	116	341	2229	2945
17	M	75	361	2414	2985	21	F	100	323	2393	2997
17	M	123	216	2178	2640	21	F	87	304	2420	2850
17	M	102	321	1975	2768	21	F	92	281	2458	2992
17	M	97	261	2210	2700	21	F	85	293	2323	2766
18	M	117	234	2348	3199	22	F	110	333	2400	3071
18	M	123	180	2340	2974	22	F	88	297	2543	3107
18	M	107	264	2201	3035	22	F	86	312	2547	3150
18	M	116	259	2255	3054	22	F	85	291	2546	2952
18	M	86	308	2187	3034	22	F	114	256	2664	3159
18	M	116	217	2177	2994	22	F	90	314	2513	3029
18	M	125	306	2215	2953	22	F	79	371	2410	2875
18	M	111	296	2104	2926	22	F	86	443	2283	2789
18	M	69	336	2114	2992	22	F	87	321	2463	3256
18	M	85	282	2214	2902	22	F	106	342	2476	3053
19	M	84	286	2188	2872	23	F	85	359	2213	2770
19	M	118	256	2259	2964	23	F	100	283	2459	2987
19	M	77	318	2240	3053	23	F	96	315	2321	2936
19	M	83	318	2152	2698	23	F	73	442	1999	2797
19	M	77	361	2201	2712	23	F	75	324	2250	2852
19	M	116	271	2265	2831	23	F	72	321	2164	2877
19	M	94	280	2276	2865	23	F	91	303	2297	2796
19	M	102	373	2116	2873	23	F	70	296	2414	2655
19	M	153	310	2263	2864	23	F	63	359	2115	2833
19	M	145	243	2326	2799	23	F	90	296	2258	2841
20	M	82	285	2089	2796	24	F	87	324	2399	2981
20	M	54	360	1853	2799	24	F	86	256	2420	3041
20	M	91	266	2138	2741	24	F	111	293	2472	3110
20	M	81	336	1959	2720	24	F	121	276	2466	3019
20	M	73	274	2125	2787	24	F	109	278	2497	3058
20	M	81	333	2115	2906	24	F	99	276	2519	2976
20	M	92	313	2022	2598	24	F	93	318	2680	3133
20	M	99	371	1876	2795	24	F	90	235	2444	3035
20	M	79	376	1886	2787	24	F	107	217	2632	3098
20	M	82	320	1972	2908	24	F	96	249	2408	3021
Avg		97	289	2174	2871	Avg		94	309	2387	2951
SD		21	48	142	131	SD		17	45	152	139

/ø/											
№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)	№	Sex	Dur (ms)	F1 (Hz)	F2 (Hz)	F3 (Hz)
17	M	116	286	1781	2850	21	F	121	319	2266	2740
17	M	101	275	1782	2649	21	F	117	315	2352	2799
17	M	146	206	1512	2632	21	F	88	297	2421	2931
17	M	99	373	2249	2966	21	F	97	304	2420	2871
17	M	134	324	1634	2486	21	F	90	310	2318	2896
17	M	119	378	1711	2756	21	F	107	259	2288	2721
17	M	89	268	1939	2679	21	F	83	279	2290	2698
17	M	114	265	2040	2835	21	F	120	337	2369	2705
17	M	98	311	1708	2763	21	F	86	273	2339	2866
17	M	105	379	1620	2715	21	F	109	245	2401	2713
18	M	122	329	2177	2906	22	F	124	294	2576	3075
18	M	90	311	2260	2858	22	F	112	282	2581	3066
18	M	68	359	2100	2980	22	F	123	314	2320	2962
18	M	100	274	2152	2876	22	F	132	375	2398	2983
18	M	125	287	2095	2804	22	F	97	338	2159	2899
18	M	98	241	2194	2970	22	F	122	349	2629	2930
18	M	142	190	2243	3054	22	F	117	319	2404	2922
18	M	132	313	2094	2822	22	F	151	272	2617	2946
18	M	109	276	2076	2875	22	F	125	311	2480	3002
18	M	146	240	2113	3070	22	F	143	270	2473	2926
19	M	132	210	2447	3147	23	F	139	302	2166	2821
19	M	80	274	2308	2970	23	F	75	368	1847	2848
19	M	147	282	2153	2946	23	F	99	299	2201	2885
19	M	124	245	2238	3026	23	F	92	350	1935	2903
19	M	112	329	2185	2778	23	F	102	319	2060	2714
19	M	99	298	2315	2975	23	F	90	338	2175	2774
19	M	111	291	2241	2780	23	F	128	276	2213	2752
19	M	115	259	2309	2895	23	F	120	240	2274	2895
19	M	106	276	2213	2968	23	F	85	333	2053	2784
19	M	89	284	2296	2862	23	F	106	346	2013	2769
20	M	86	377	1919	2781	24	F	100	330	2378	2924
20	M	97	304	1947	2577	24	F	107	298	2528	2975
20	M	130	321	2052	2698	24	F	108	286	2493	3100
20	M	104	296	2070	2613	24	F	95	275	2453	3152
20	M	95	346	1937	2746	24	F	92	310	2384	2975
20	M	68	275	2147	2755	24	F	105	267	2229	2932
20	M	94	274	2107	2909	24	F	89	334	2227	2822
20	M	101	265	2127	2791	24	F	115	312	2335	2876
20	M	112	290	2021	2951	24	F	100	297	2485	2997
20	M	111	250	2244	2672	24	F	102	302	2452	3035
Avg		109	291	2069	2835	Avg		108	306	2325	2890
SD		20	46	218	146	SD		18	32	181	116

Appendix B. Welch's Two-sided t-tests[27]

- H_0: the difference in means for the feature value between both vowels in the pair is not significant (p > 0.05)
- H_A: the difference in means for the feature value between both vowels in the pair is significant (p < 0.05; indicated in green)

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Duration		
variety	sex	Welch t-test result
SSD	Male	*t = -12.3926, df = 48.828, p-value < 0.001*
	Female	*t = -5.2986, df = 66.386, p-value < 0.001*
NSD	Male	*t = -6.6664, df = 57.551, p-value < 0.001*
	Female	*t = -6.2782, df = 70.452, p-value < 0.001*
Afrikaans	Male	*t = -5.4895, df = 50.621, p-value < 0.001*
	Female	*t = -5.1763, df = 66.547, p-value < 0.001*

F1		
variety	sex	Welch t-test result
SSD	Male	*t = 25.3024, df = 60.383, p-value < 0.001*
	Female	*t = 21.1852, df = 77.861, p-value < 0.001*
NSD	Male	*t = 20.7211, df = 76.95, p-value < 0.001*
	Female	*t = 31.3489, df = 71.501, p-value < 0.001*
Afrikaans	Male	*t = 16.2784, df = 76.007, p-value < 0.001*
	Female	*t = 27.3856, df = 70.368, p-value < 0.001*

F2		
variety	sex	Welch t-test result
SSD	Male	*t = -5.1621, df = 68.529, p-value < 0.001*
	Female	*t = 18.4847, df = 77.975, p-value < 0.001*
NSD	Male	*t = 17.479, df = 76.204, p-value < 0.001*
	Female	*t = 19.1782, df = 77.995, p-value < 0.001*
Afrikaans	Male	t = -1.4234, df = 74.071, p-value = 0.1588
	Female	t = 0.2243, df = 74.705, p-value = 0.8232

F3		
variety	sex	Welch t-test result
SSD	Male	*t = 21.672, df = 72.686, p-value < 0.001*
	Female	*t = 12.7329, df = 77.319, p-value < 0.001*
NSD	Male	t = 2.2735, df = 66.103, p-value = 0.02625
	Female	*t = 10.8933, df = 54.905, p-value < 0.001*
Afrikaans	Male	t = 0.0053, df = 69.598, p-value = 0.9958
	Female	t = 1.9847, df = 77.336, p-value = 0.05073

[27] The same significance color codes are used as in Tables 5.1 to 5.6 of the study.

2 /ɪ - ʏ/

Duration		
variety	sex	Welch t-test result
SSD	Male	*t = -5.2703, df = 77.912, p-value < 0.001*
	Female	*t = -7.8289, df = 71.301, p-value < 0.001*
NSD	Male	*t = -5.7304, df = 76.064, p-value < 0.001*
	Female	*t = -5.0052, df = 62.673, p-value < 0.001*
Afrikaans	Male	*t = -4.7515, df = 77.287, p-value < 0.001*
	Female	*t = -5.5588, df = 69.489, p-value < 0.001*

F1		
variety	sex	Welch t-test result
SSD	Male	*t = 33.9897, df = 41.786, p-value < 0.001*
	Female	*t = 33.2991, df = 41.771, p-value < 0.001*
NSD	Male	*t = 38.3774, df = 43.662, p-value < 0.001*
	Female	*t = 42.2001, df = 48.628, p-value < 0.001*
Afrikaans	Male	*t = 8.8522, df = 39.02, p-value < 0.001*
	Female	*t = 27.424, df = 40.764, p-value < 0.001*

F2		
variety	sex	Welch t-test result
SSD	Male	*t = 14.7257, df = 77.617, p-value < 0.001*
	Female	*t = 16.1275, df = 75.404, p-value < 0.001*
NSD	Male	*t = 8.9364, df = 62.108, p-value < 0.001*
	Female	*t = 16.3016, df = 72.104, p-value < 0.001*
Afrikaans	Male	t = 0.6945, df = 74.349, p-value = 0.4895
	Female	*t = 6.1589, df = 77.987, p-value = < 0.001*

F3		
variety	sex	Welch t-test result
SSD	Male	t = 0.283, df = 62.73, p-value = 0.7781
	Female	*t = 13.4891, df = 77.975, p-value < 0.001*
NSD	Male	t = -1.6772, df = 59.651, p-value = 0.09874
	Female	*t = 4.2088, df = 70.09, p-value < 0.001*
Afrikaans	Male	t = 2.3631, df = 70.063, p-value = 0.0209
	Female	t = 2.0594, df = 76.916, p-value = 0.04284

3 /ɪ - ə/

Duration		
variety	sex	Welch t-test result
SSD	Male	t = 0.6967, df = 76.181, p-value = 0.4881
	Female	t = -2.2524, df = 70.913, p-value = 0.02739
NSD	Male	t = 0.2578, df = 77.809, p-value = 0.7973
	Female	t = 0.3311, df = 71.883, p-value = 0.7415
Afrikaans	Male	t = 1.972, df = 73.442, p-value = 0.05238
	Female	t = 0.4559, df = 69.754, p-value = 0.6499

F1		
variety	sex	Welch t-test result
SSD	Male	*t = 27.1222, df = 40.315, p-value < 0.001*
	Female	*t = 34.5614, df = 41.83, p-value < 0.001*
NSD	Male	*t = 20.024, df = 39.645, p-value < 0.001*
	Female	*t = 45.2163, df = 44.996, p-value < 0.001*
Afrikaans	Male	*t = 8.3244, df = 39.018, p-value < 0.001*
	Female	*t = 28.5169, df = 40.739, p-value < 0.001*

F2		
variety	sex	Welch t-test result
SSD	Male	*t = -11.706, df = 64.109, p-value < 0.001*
	Female	*t = 17.0045, df = 66.552, p-value < 0.001*
NSD	Male	*t = -10.1672, df = 60.685, p-value < 0.001*
	Female	*t = 15.1735, df = 75.985, p-value < 0.001*
Afrikaans	Male	t = -0.2097, df = 77.982, p-value = 0.8344
	Female	*t = 3.0997, df = 75.655, p-value = 0.00272*

F3		
variety	sex	Welch t-test result
SSD	Male	t = 0.4073, df = 60.047, p-value = 0.6852
	Female	*t = 3.5131, df = 77.249, p-value = 0.001*
NSD	Male	t = 1.5906, df = 57.612, p-value = 0.1172
	Female	t = -0.4102, df = 71.347, p-value = 0.6829
Afrikaans	Male	t = -1.6169, df = 77.941, p-value = 0.1099
	Female	t = 1.1508, df = 70.021, p-value = 0.2537

4 /ɤ - ə/

Duration		
variety	sex	Welch t-test result
SSD	Male	***t = -4.1271, df = 75.362, p-value < 0.001***
	Female	***t = 4.8389, df = 77.991, p-value < 0.001***
NSD	Male	***t = -5.6121, df = 74.784, p-value < 0.001***
	Female	***t = 4.808, df = 73.852, p-value < 0.001***
Afrikaans	Male	t = -2.2698, df = 76.128, p-value = 0.02605
	Female	***t = 5.193, df = 77.996, p-value < 0.001***

F1		
variety	sex	Welch t-test result
SSD	Male	***t = 26.1921, df = 40.23, p-value < 0.001***
	Female	***t = 35.0357, df = 41.734, p-value < 0.001***
NSD	Male	***t = 19.1933, df = 39.89, p-value < 0.001***
	Female	***t = 31.2048, df = 41.575, p-value < 0.001***
Afrikaans	Male	***t = 8.217, df = 39.022, p-value < 0.001***
	Female	***t = 30.8535, df = 41.058, p-value < 0.001***

F2		
variety	sex	Welch t-test result
SSD	Male	t = -0.5303, df = 66.84, p-value = 0.5977
	Female	t = -0.6947, df = 73.471, p-value = 0.4895
NSD	Male	t = -1.2266, df = 77.883, p-value = 0.2237
	Female	t = -0.3812, df = 76.721, p-value = 0.7041
Afrikaans	Male	t = 0.4567, df = 73.888, p-value = 0.6492
	Female	t = -2.5135, df = 75.965, p-value = 0.01407

F3		
variety	sex	Welch t-test result
SSD	Male	t = 0.5622, df = 77.585, p-value = 0.5756
	Female	***t = -9.3333, df = 77.492, p-value < 0.001***
NSD	Male	t = -0.0074, df = 77.72, p-value = 0.9941
	Female	***t = -4.0557, df = 77.91, p-value = < 0.001***
Afrikaans	Male	t = 0.5285, df = 71.082, p-value = 0.5988
	Female	t = -1.1886, df = 74.146, p-value = 0.2384

5 /e – ø/

Duration		
variety	sex	Welch t-test result
SSD	Male	t = -0.7284, df = 66.393, p-value = 0.469
	Female	t = -2.015, df = 70.824, p-value = 0.0477
NSD	Male	***t = -4.144, df = 73.177, p-value <0.001***
	Female	t = -0.9701, df = 78, p-value = 0.335
Afrikaans	Male	***t = -2.6910, df = 77.815, p-value = 0.009***
	Female	***t = -3.6052, df = 77.729, p-value = 0.001***

F1		
variety	sex	Welch t-test result
SSD	Male	***t = 30.8498, df = 66.53, p-value < 0.001***
	Female	***t = 23.075, df = 52.223, p-value < 0.001***
NSD	Male	***t = 28.1532, df = 45.28, p-value < 0.001***
	Female	***t = 24.5261, df = 46.457, p-value < 0.001***
Afrikaans	Male	***t = 21.7763, df = 51.804, p-value < 0.001***
	Female	***t = 26.4506, df = 50.657, p-value < 0.001***

F2		
variety	sex	Welch t-test result
SSD	Male	***t = 14.0713, df = 65.649, p-value < 0.001***
	Female	***t = 27.6838, df = 67.597, p-value < 0.001***
NSD	Male	***t = 6.893, df = 55.558, p-value < 0.001***
	Female	***t = 20.7228, df = 77.709, p-value < 0.001***
Afrikaans	Male	t = 2.5614, df = 67.151, p-value = 0.01268
	Female	t = 1.6467, df = 75.801, p-value = 0.1038

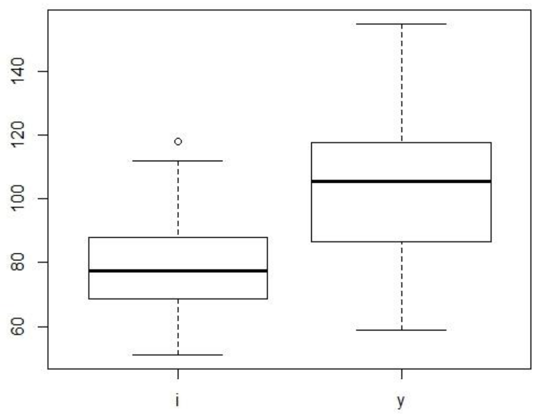
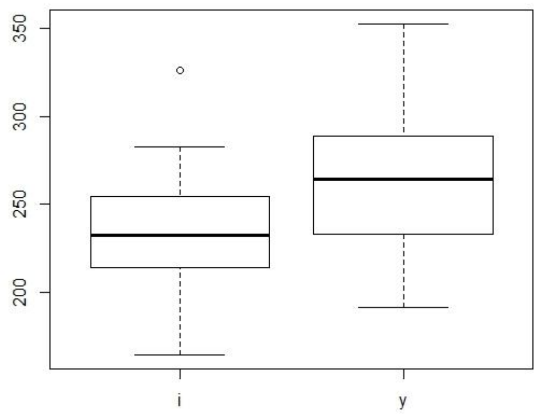
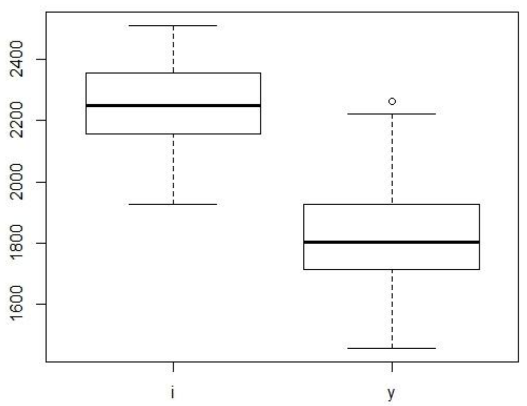
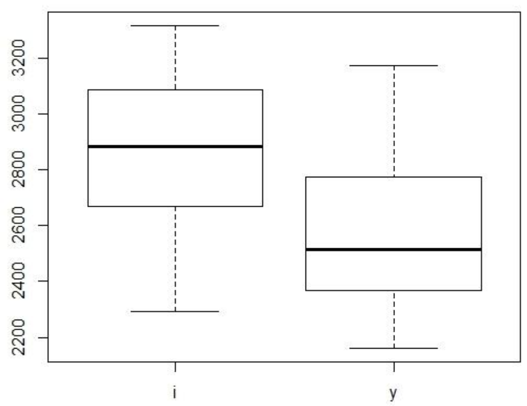
F3		
variety	sex	Welch t-test result
SSD	Male	t = 2.1889, df = 54.274, p-value = 0.03293
	Female	***t = 23.3046, df = 77.837, p-value < 0.001***
NSD	Male	t = 0.7368, df = 54.369, p-value = 0.4644
	Female	***t = 9.9913, df = 77.852, p-value < 0.001***
Afrikaans	Male	t = 1.186, df = 77.092, p-value = 0.2393
	Female	t = 2.1311, df = 75.623, p-value = 0.03633

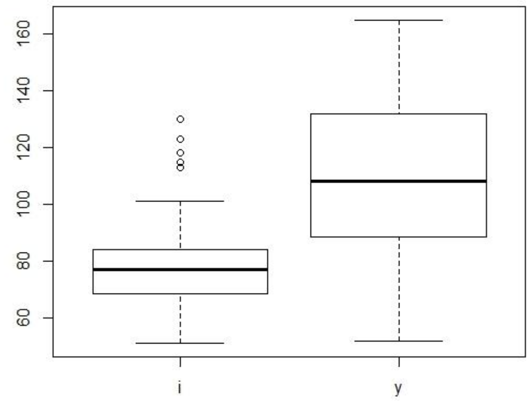
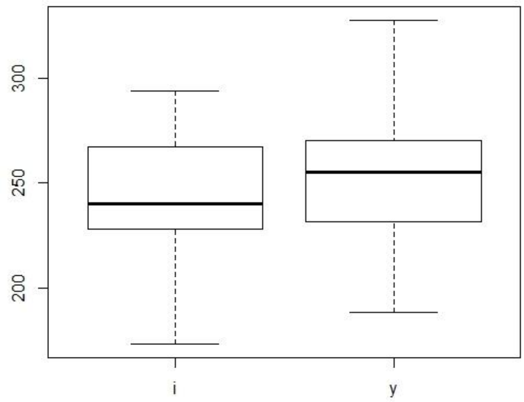
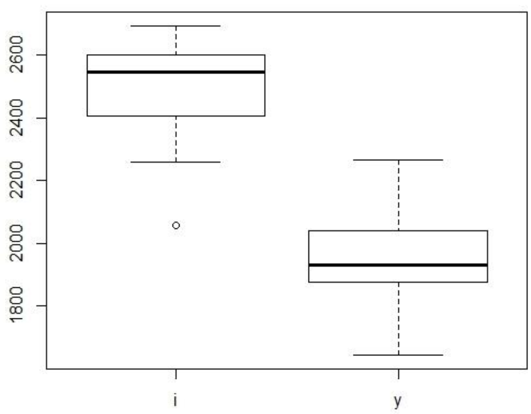
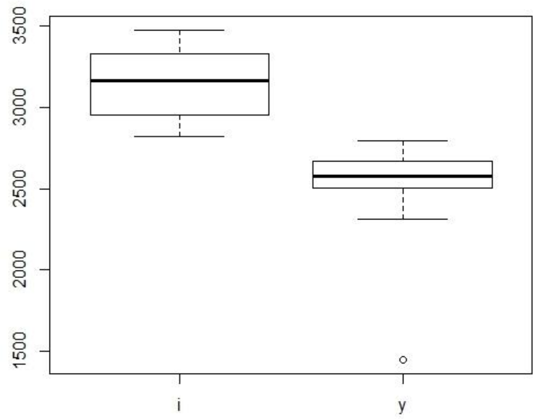
Appendix C. Within-language contrast differences (box plots)

This appendix presents box plots of the values of the features for each vowel pair, grouped per variety, contrast and sex. These box plots thus provide a visualization of the data on which the Welch’s two-sided t-tests presented in the previous appendix are based.

1 Southern Standard Dutch

1. 1 /i - y/

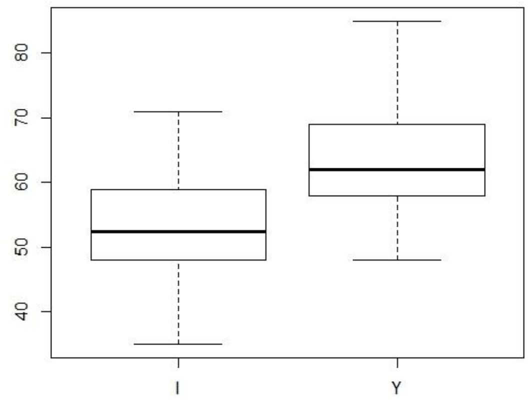
Male	
Duration (ms)	F1 (Hz)
	
F2 (Hz)	F3 (Hz)
	

Female	
Duration (ms)	F1 (Hz)
	
F2 (Hz)	F3 (Hz)
	

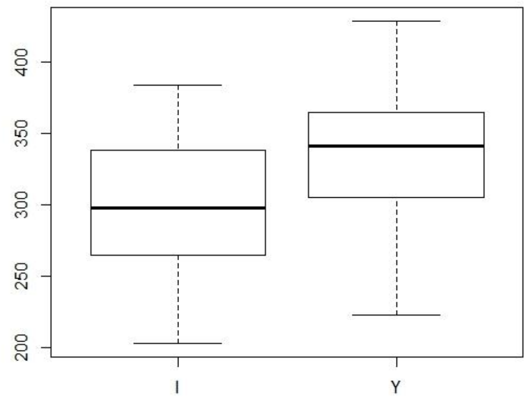
1.2 /ɪ - ʏ/

Male

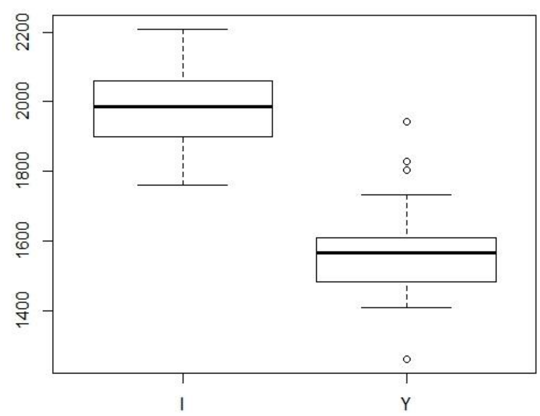
Duration (ms)



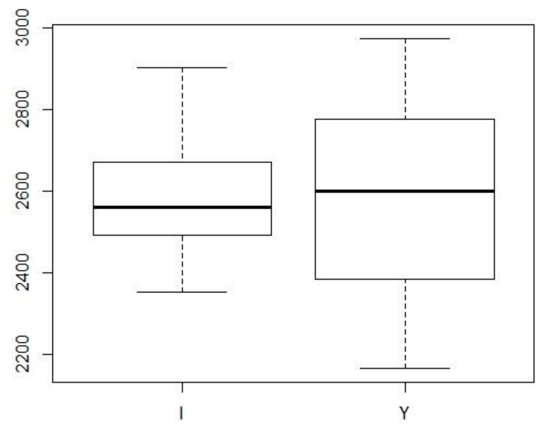
F1 (Hz)



F2 (Hz)

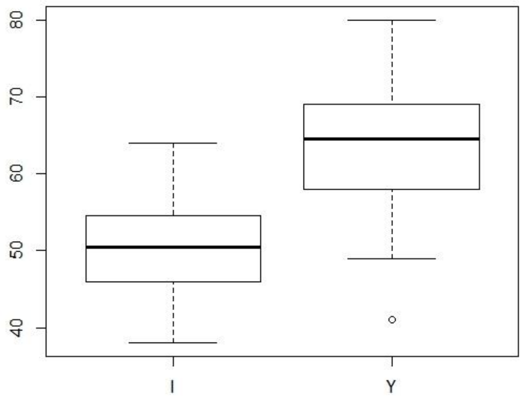


F3 (Hz)

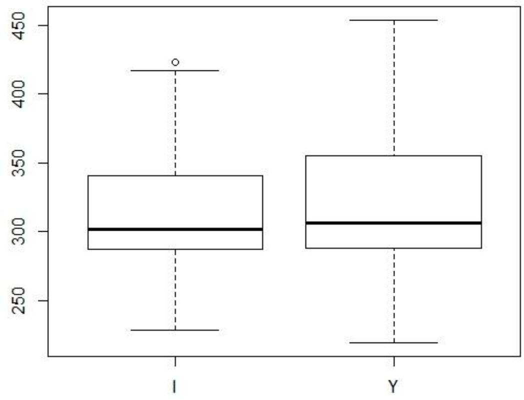


Female

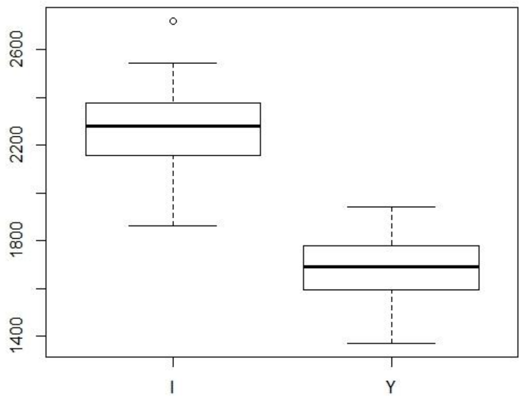
Duration (ms)



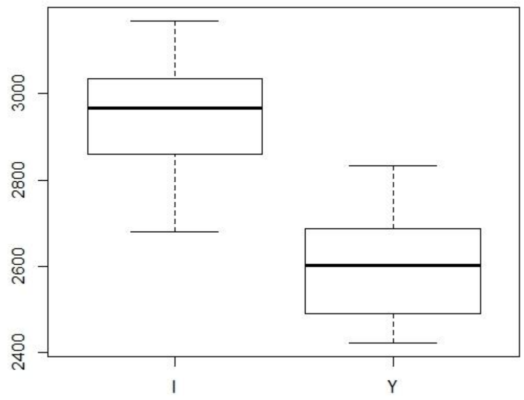
F1 (Hz)



F2 (Hz)



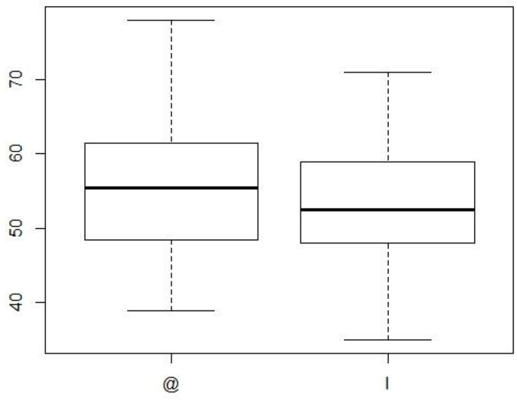
F3 (Hz)



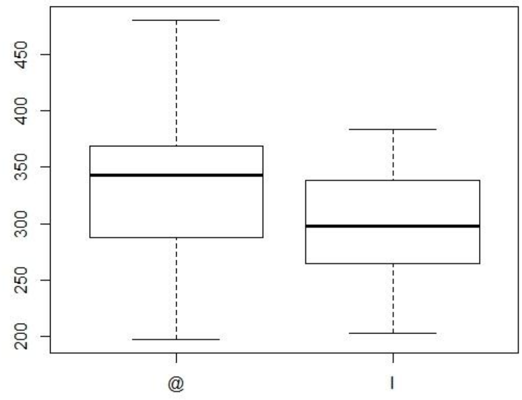
1.3 /ɪ - ə/

Male

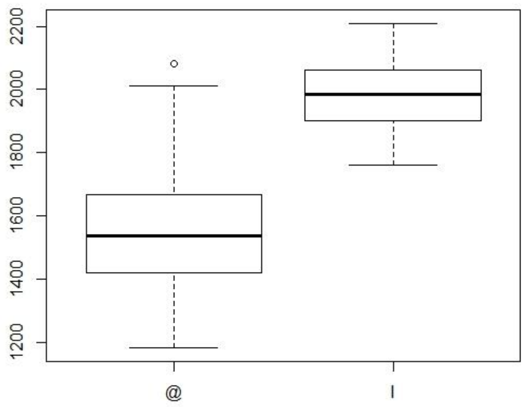
Duration (ms)



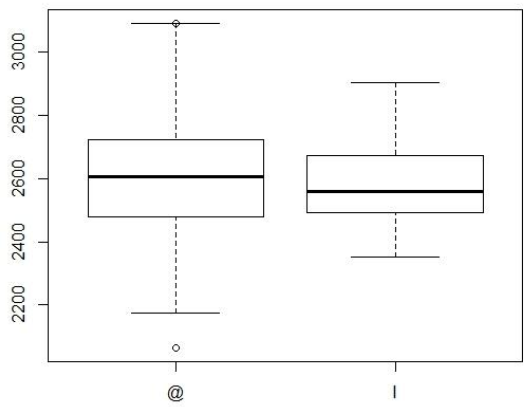
F1 (Hz)

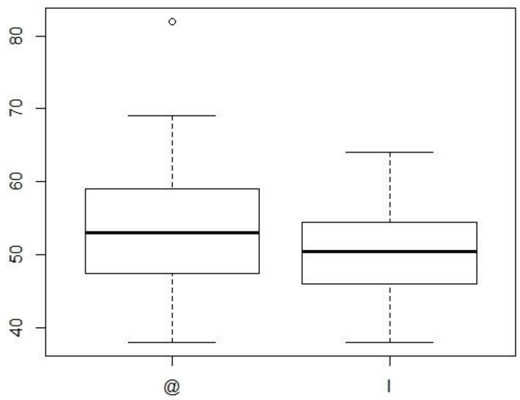
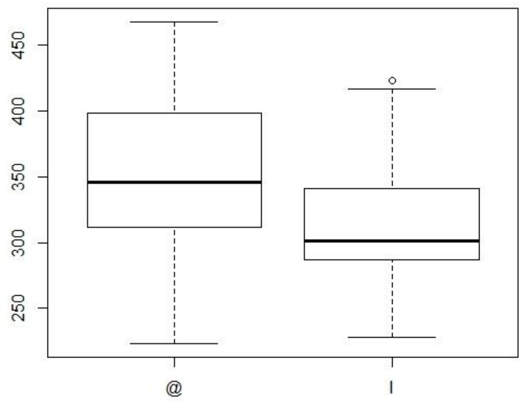
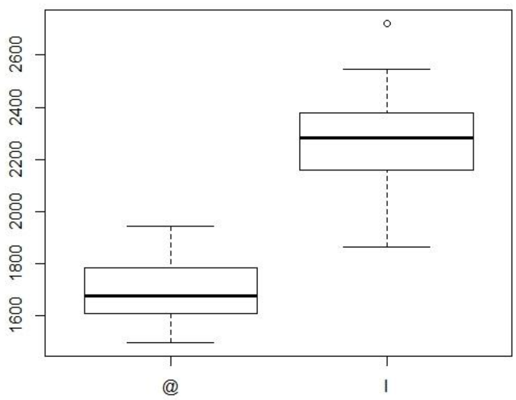
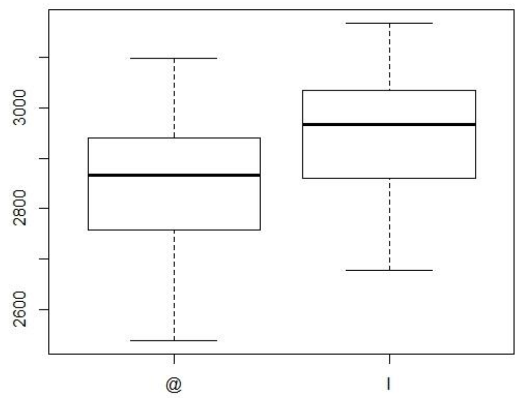


F2 (Hz)



F3 (Hz)



<table>
<tr><th colspan="2">Female</th></tr>
<tr><th>Duration (ms)</th><th>F1 (Hz)</th></tr>
<tr><td></td><td></td></tr>
<tr><th>F2 (Hz)</th><th>F3 (Hz)</th></tr>
<tr><td></td><td></td></tr>
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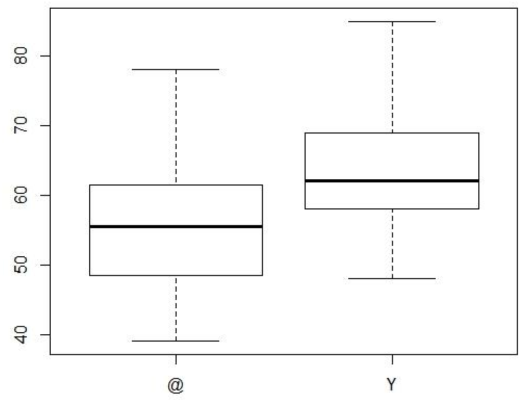
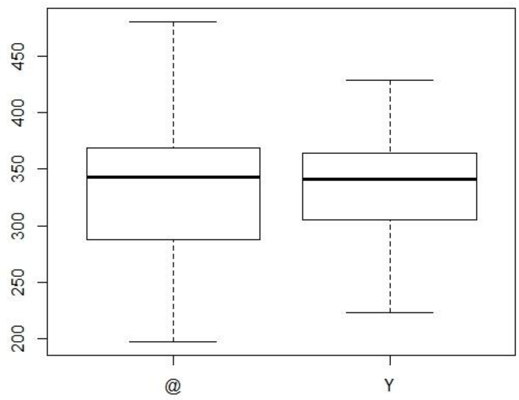
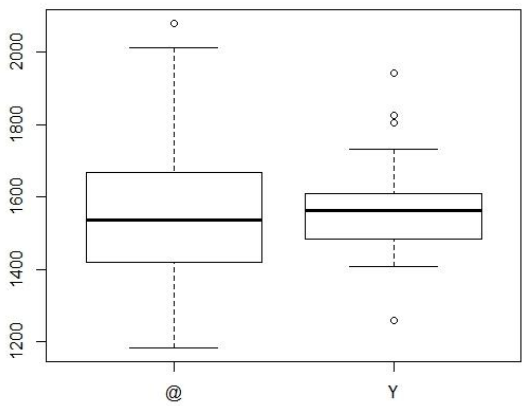
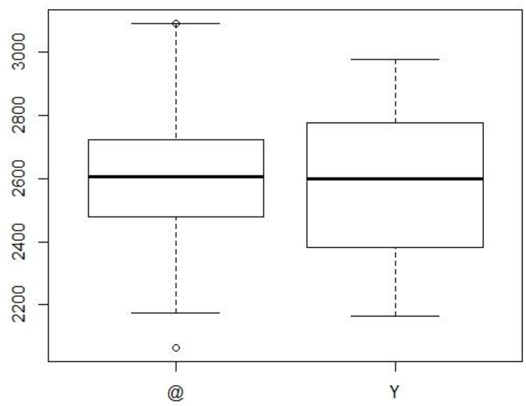
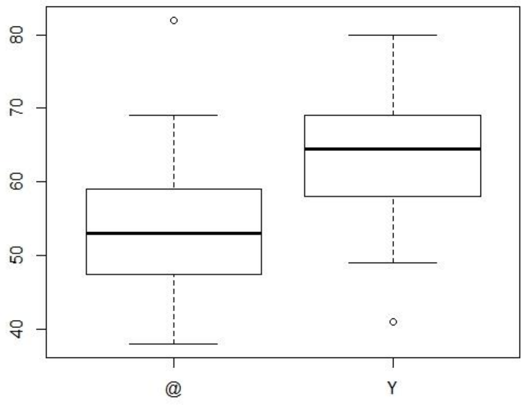
1.4 /ʏ - ə/

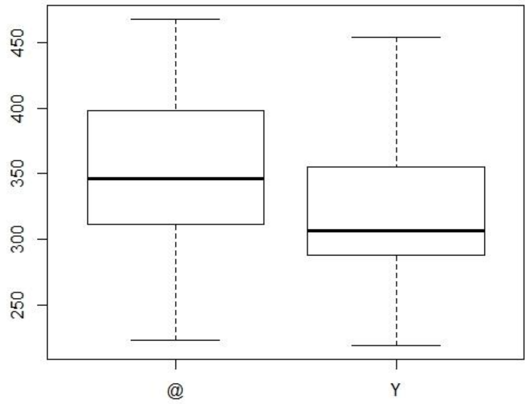
Male	
Duration (ms)	**F1 (Hz)**
	
F2 (Hz)	**F3 (Hz)**
	

Female

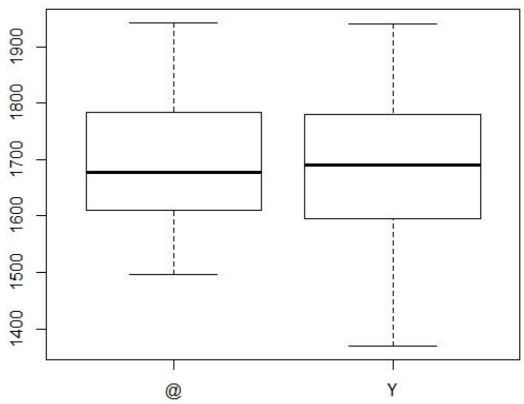
Duration (ms)



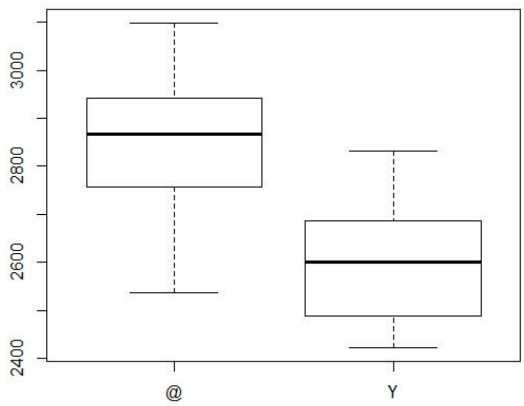
F1 (Hz)



F2 (Hz)



F3 (Hz)



1.5 /e - ø/

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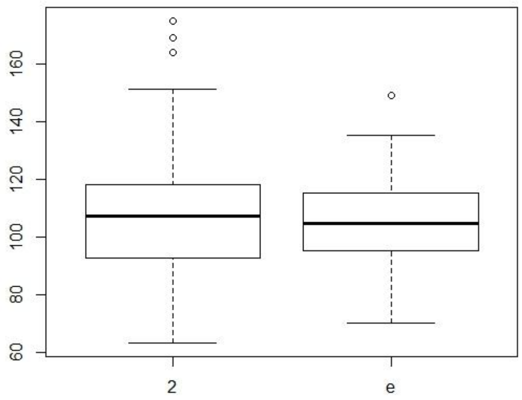
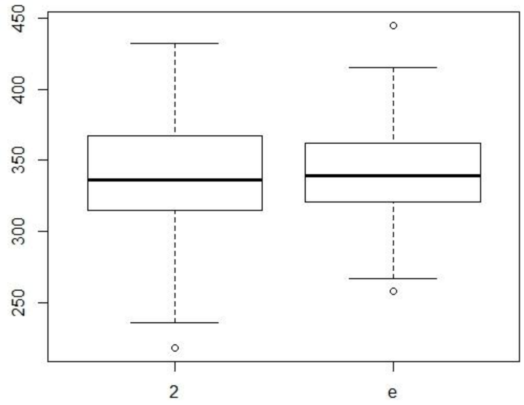
<tr><td>
</td><td>
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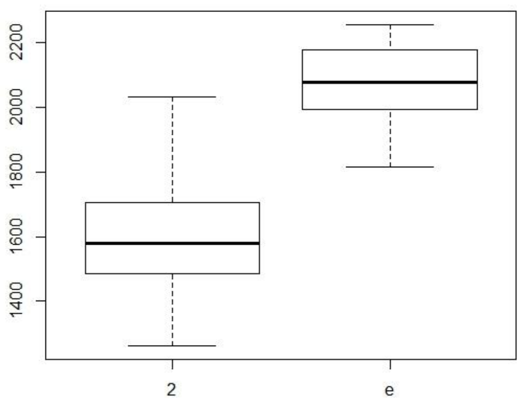
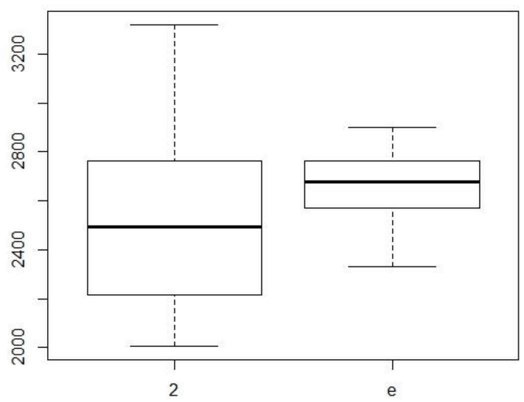
<tr><th>F2 (Hz)</th><th>F3 (Hz)</th></tr>
<tr><td>
</td><td>
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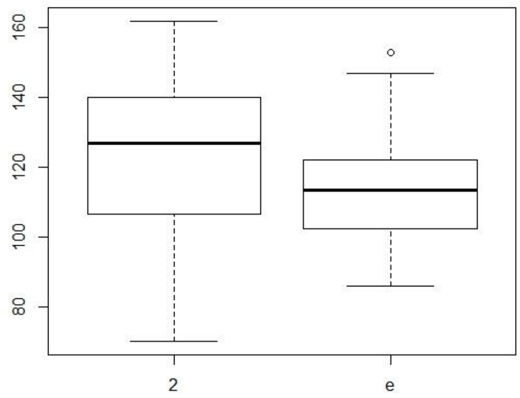
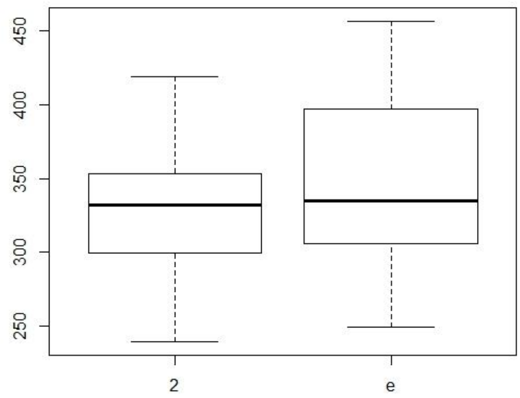
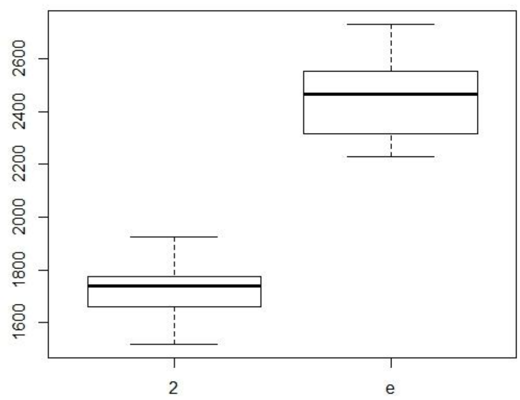
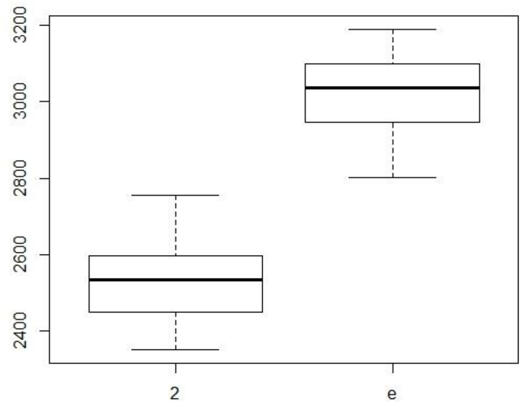
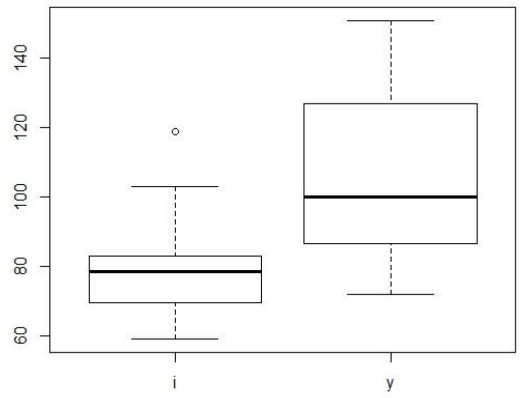
Female	
Duration (ms)	**F1 (Hz)**
	
F2 (Hz)	**F3 (Hz)**
	

2 Northern Standard Dutch

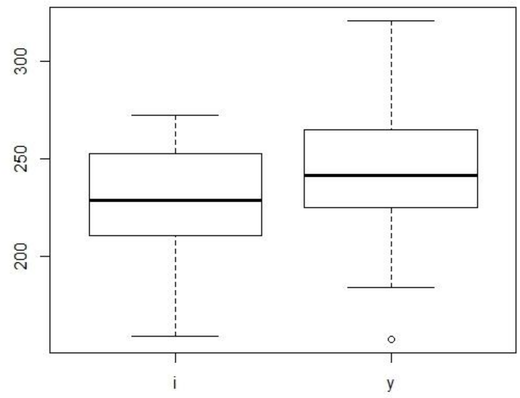
2.1 /i - y/

Male

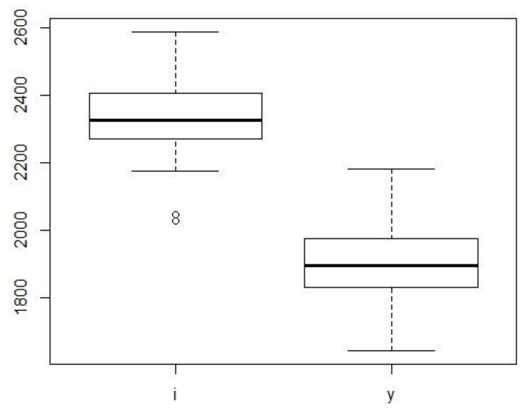
Duration (ms)



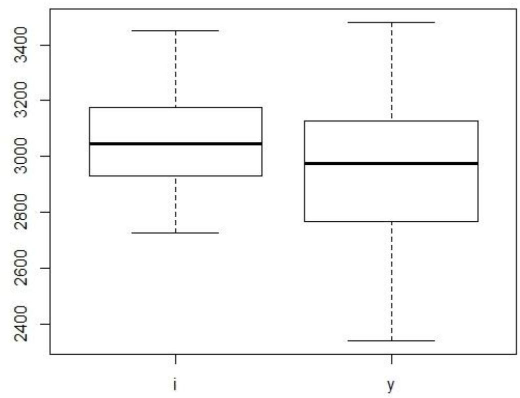
F1 (Hz)



F2 (Hz)

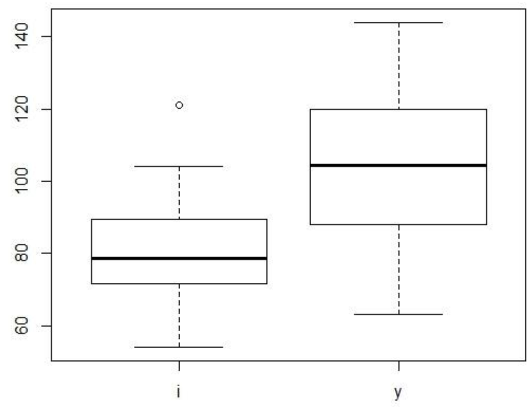


F3 (Hz)

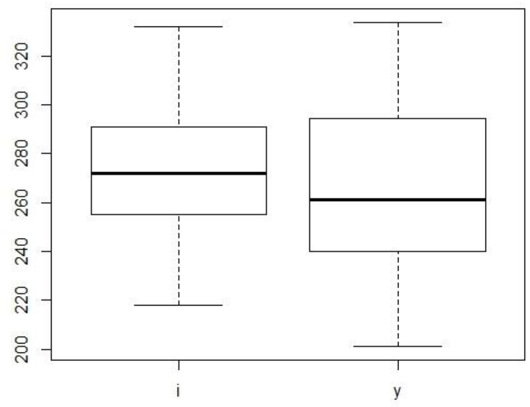


Female

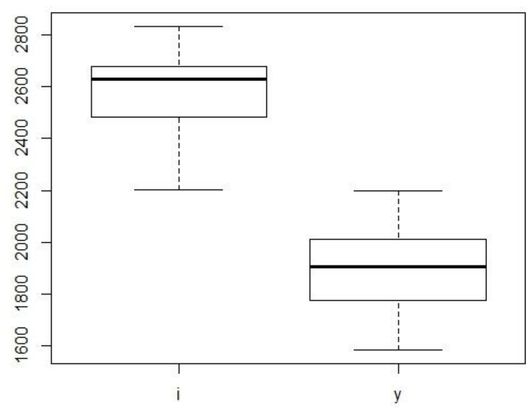
Duration (ms)



F1 (Hz)



F2 (Hz)



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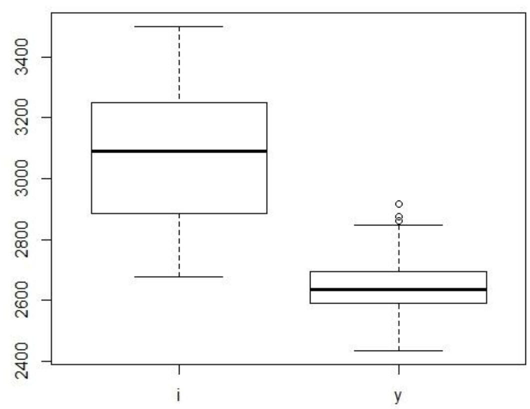
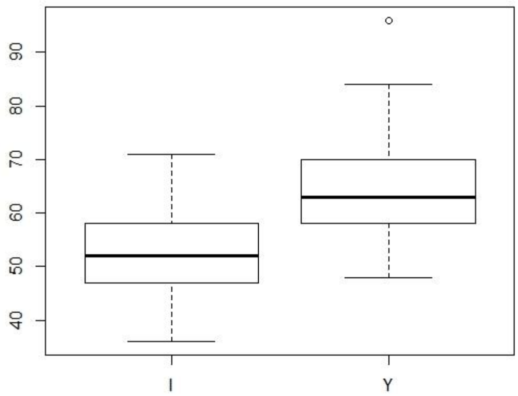
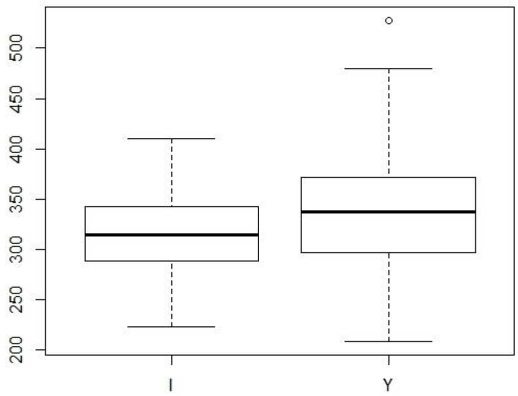
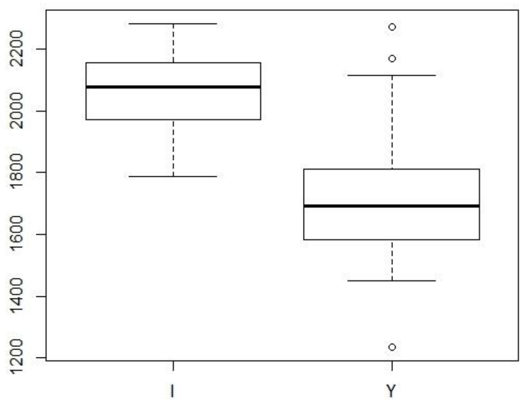
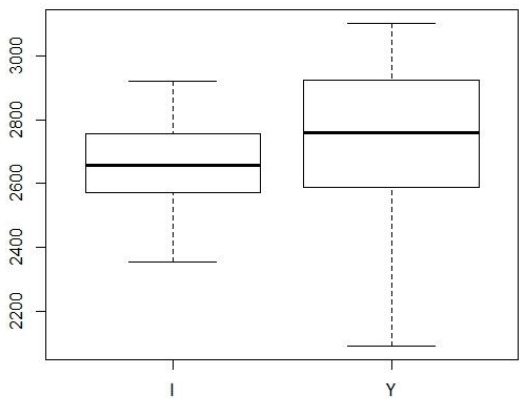
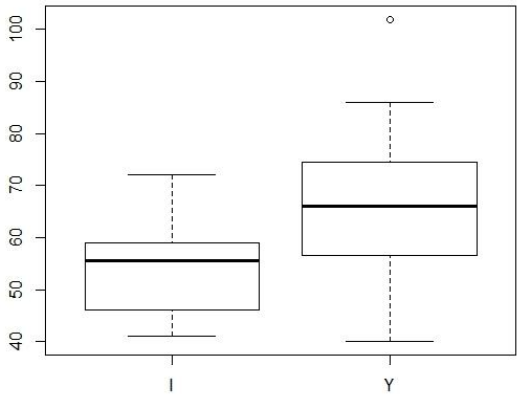
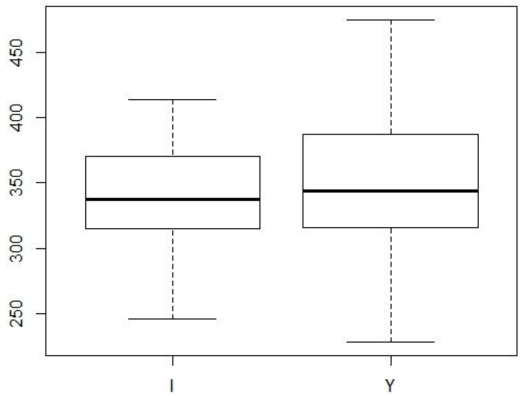
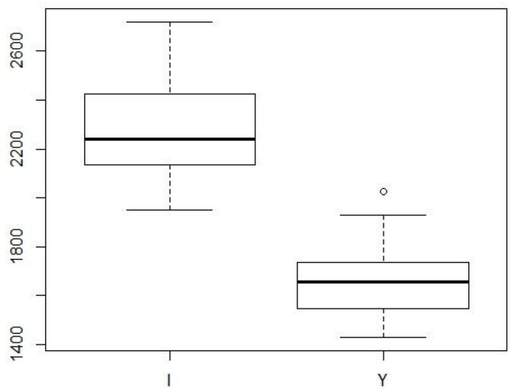
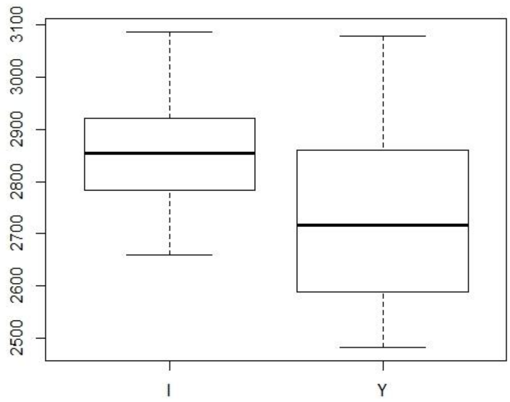


2.2 /ɪ - ʏ/

Male	
Duration (ms)	**F1 (Hz)**
	
F2 (Hz)	**F3 (Hz)**
	

Female	
Duration (ms)	F1 (Hz)
	
F2 (Hz)	F3 (Hz)
	

2.3 /ɪ - ə/

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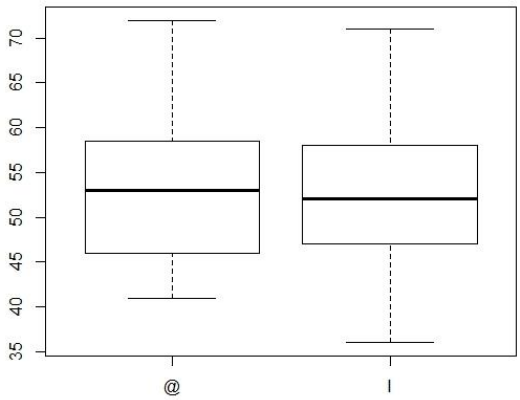
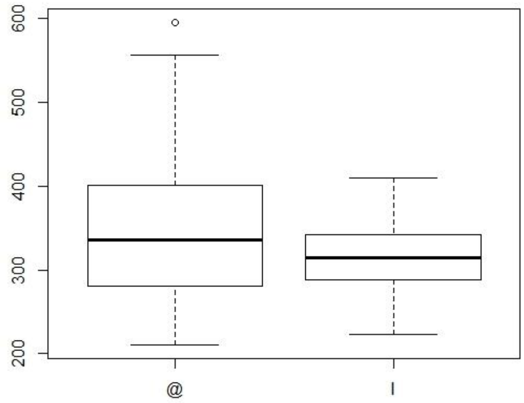
<tr><td>
</td><td>
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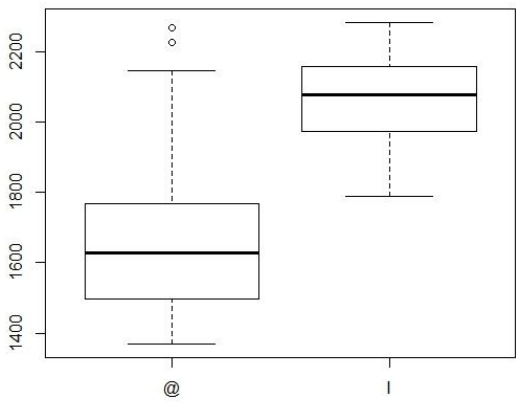
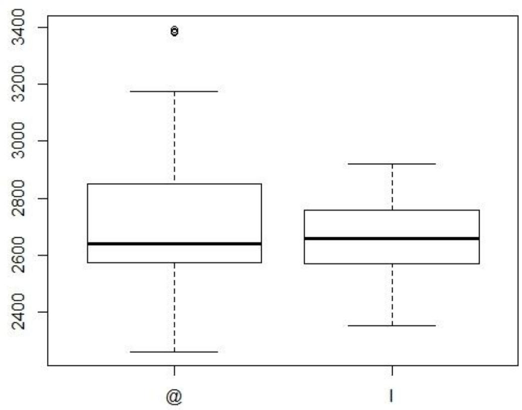
<tr><td>
</td><td>
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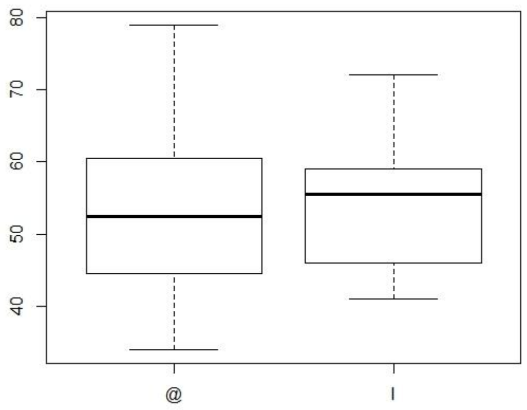
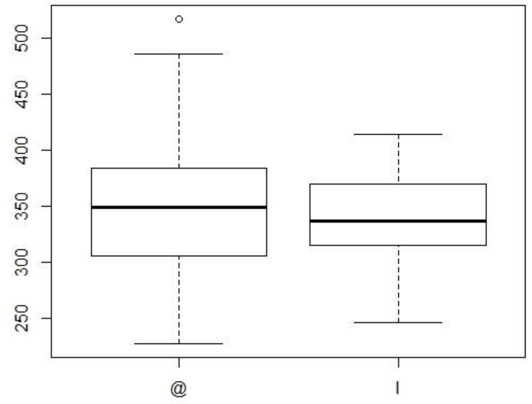
Female

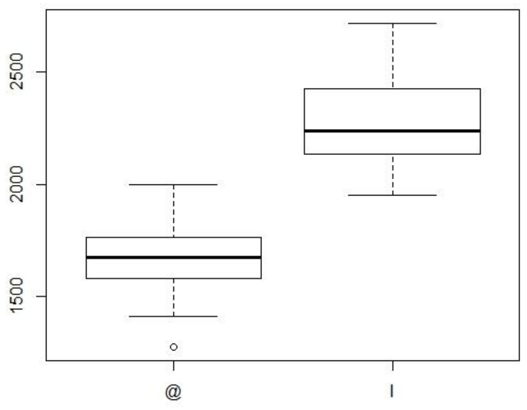
Duration (ms)



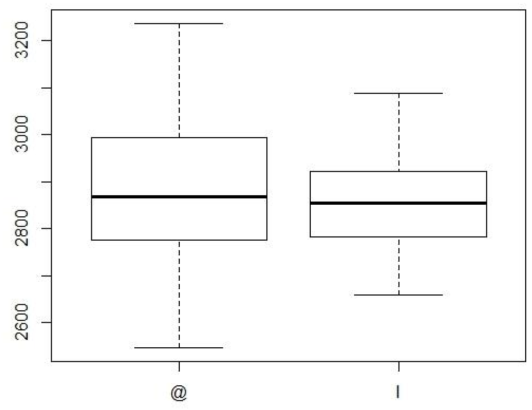
F1 (Hz)



F2 (Hz)



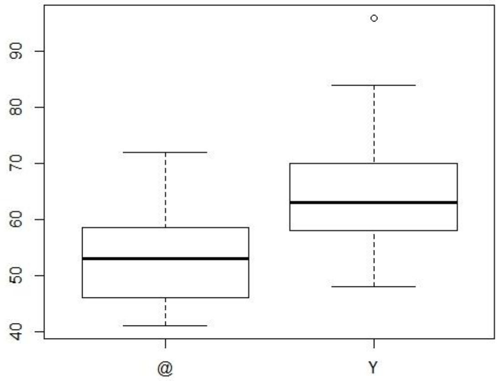
F3 (Hz)



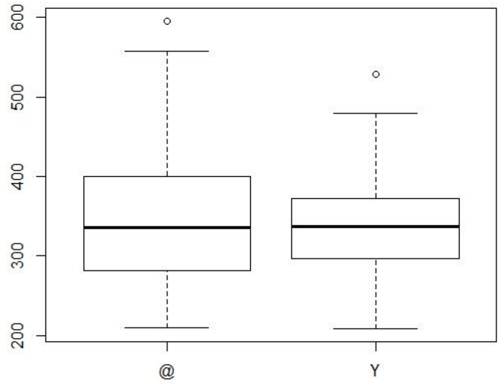
2.4 /ʏ - ə/

Male

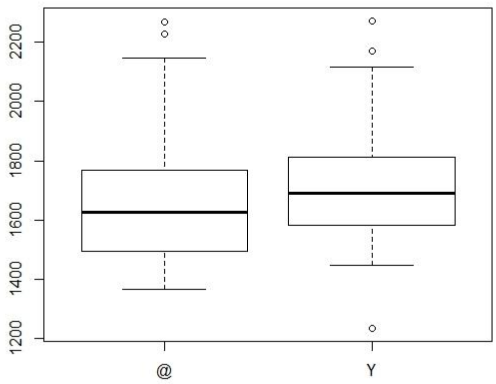
Duration (ms)



F1 (Hz)



F2 (Hz)



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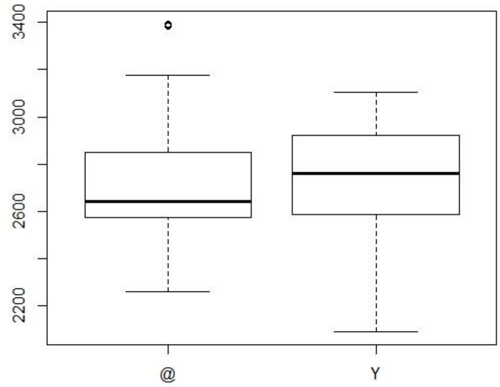
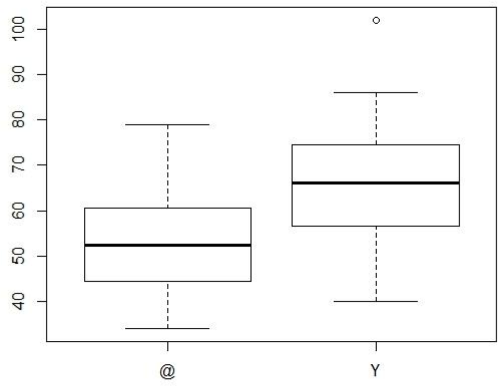
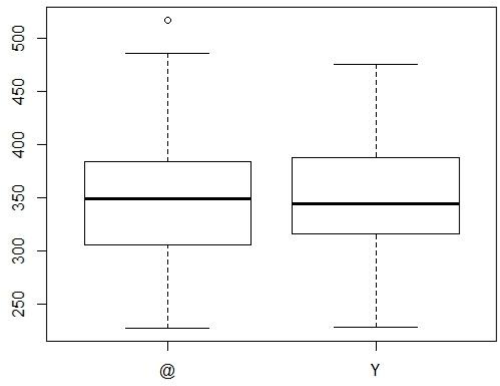


Female

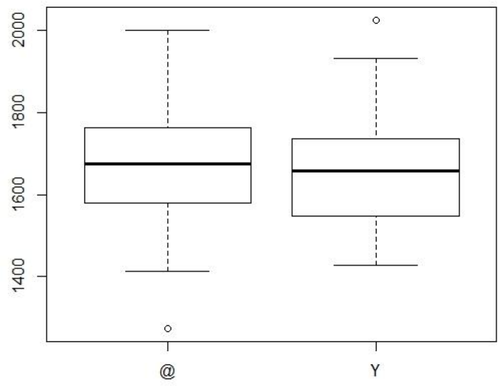
Duration (ms)



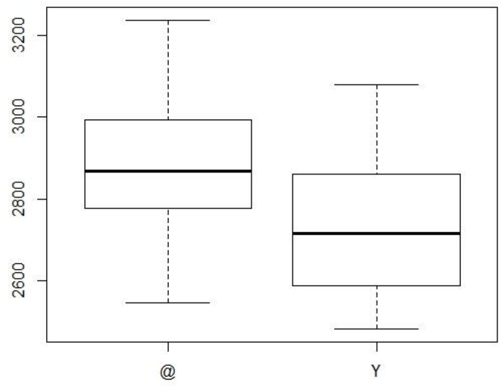
F1 (Hz)



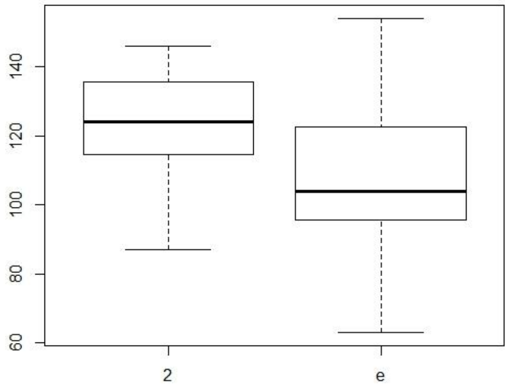
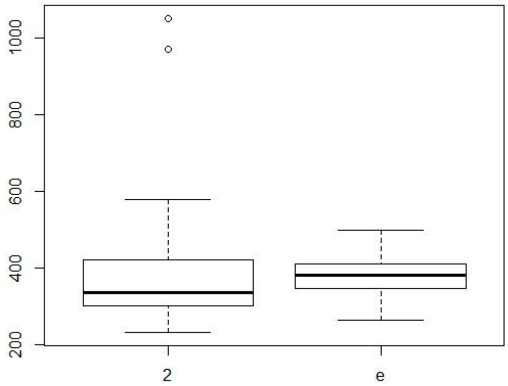
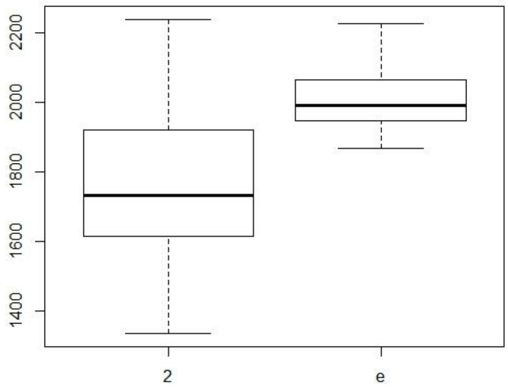
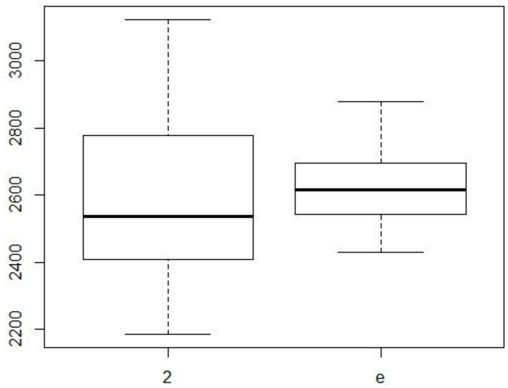
F2 (Hz)

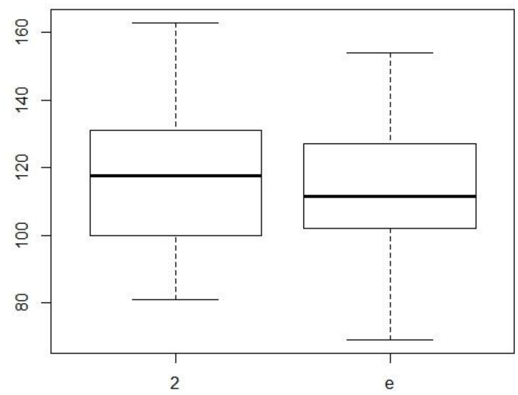
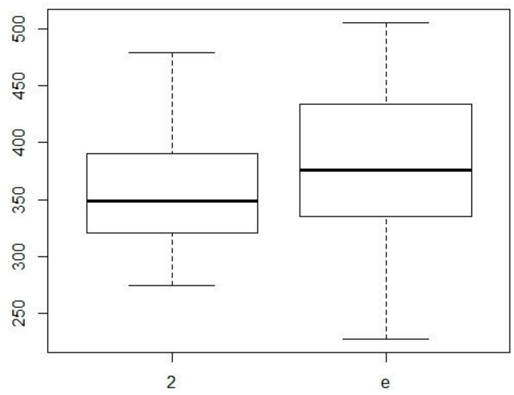
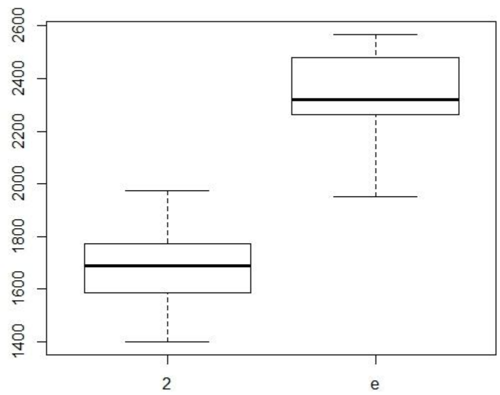
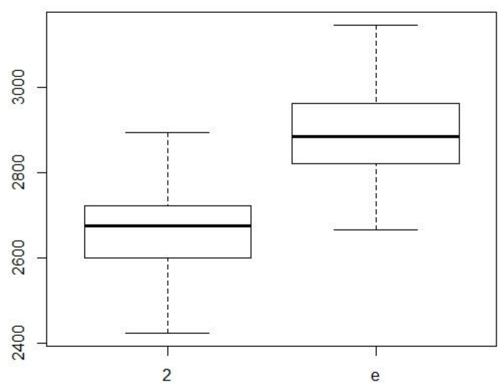


F3 (Hz)



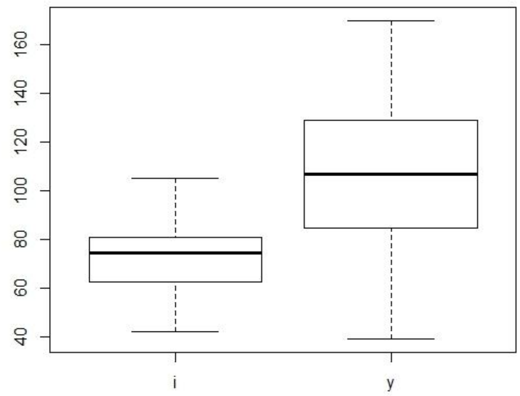
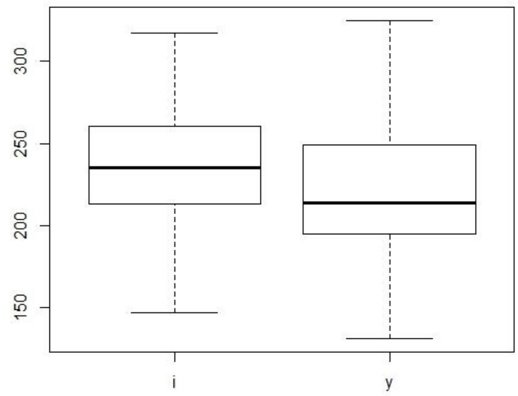
2.5 /e – ø/

Male	
Duration (ms)	**F1 (Hz)**
	
F2 (Hz)	**F3 (Hz)**
	

Female	
Duration (ms)	F1 (Hz)
	
F2 (Hz)	F3 (Hz)
	

3 Afrikaans

3.1 /i - y/

Male	
Duration (ms)	**F1 (Hz)**
	
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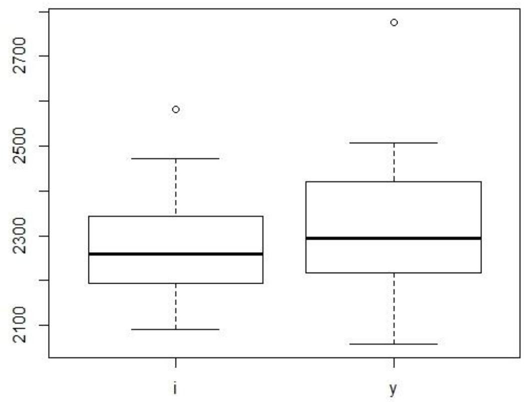
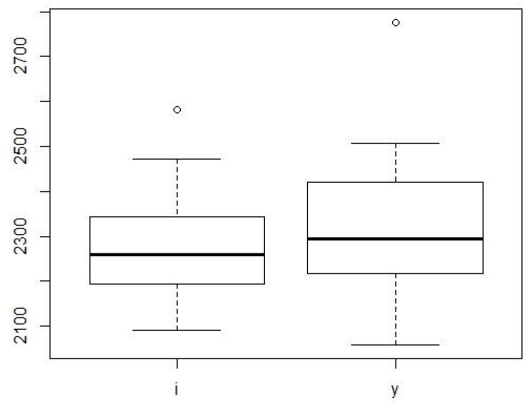
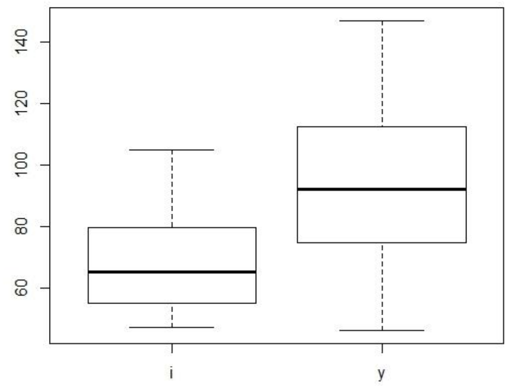
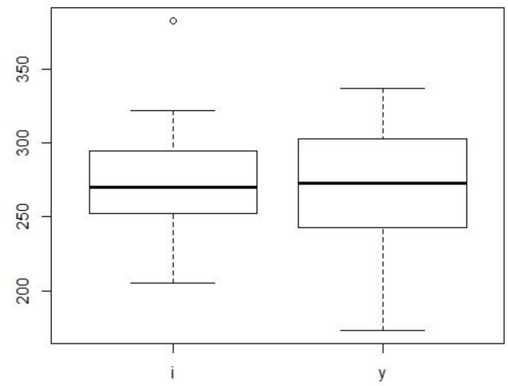
	

Female

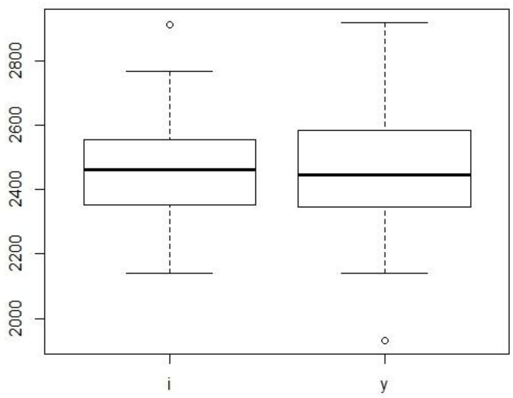
Duration (ms)



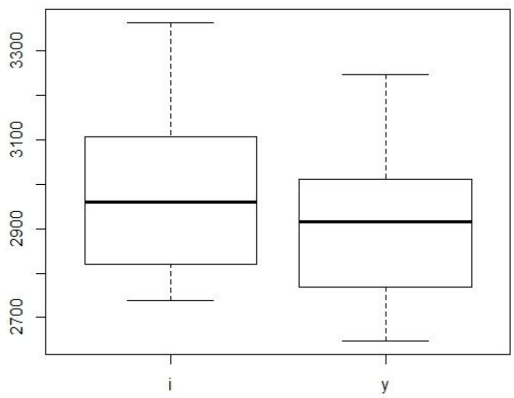
F1 (Hz)



F2 (Hz)



F3 (Hz)



3.2 /ɪ - ʏ/

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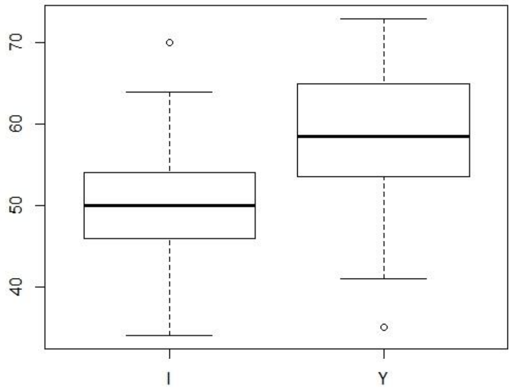
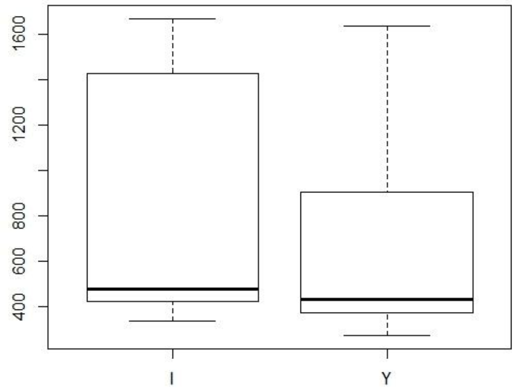
<tr><td>
</td><td>
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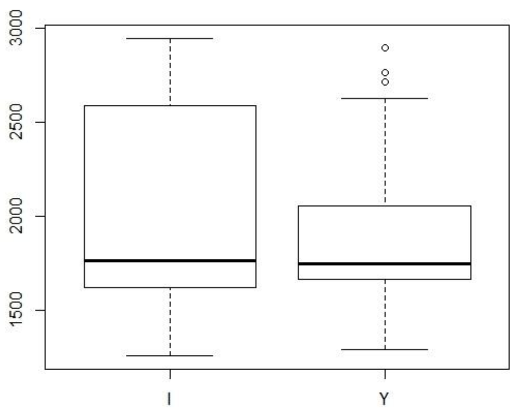
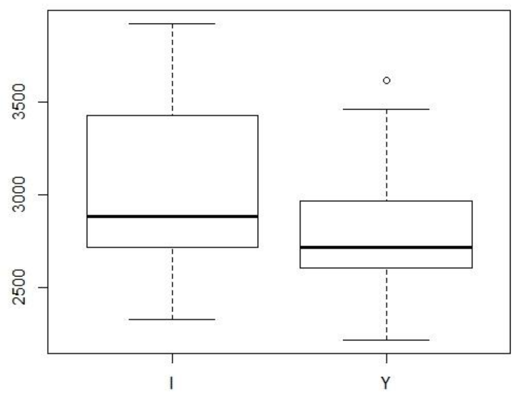
<tr><td>
</td><td>
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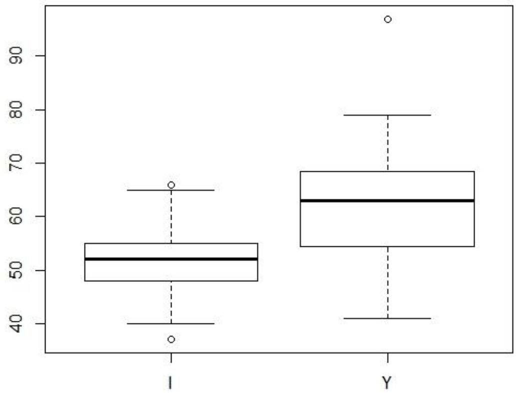
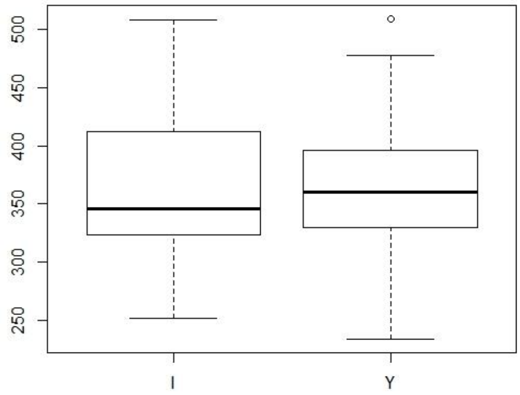
Female

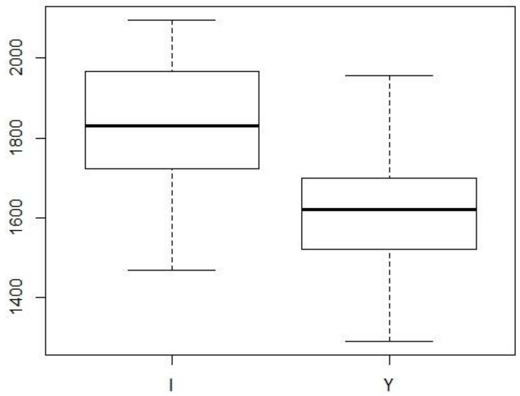
Duration (ms)



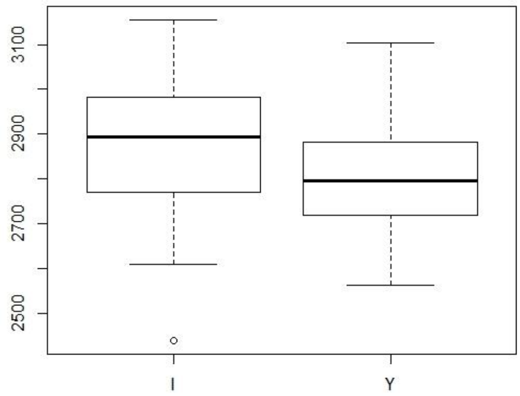
F1 (Hz)



F2 (Hz)



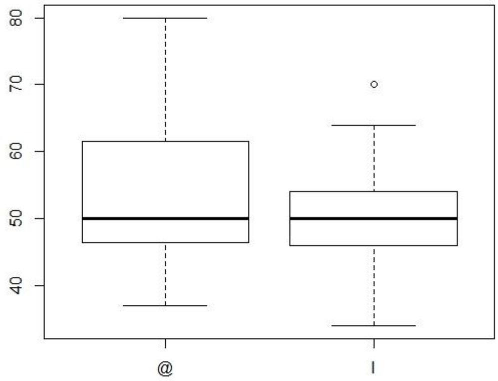
F3 (Hz)



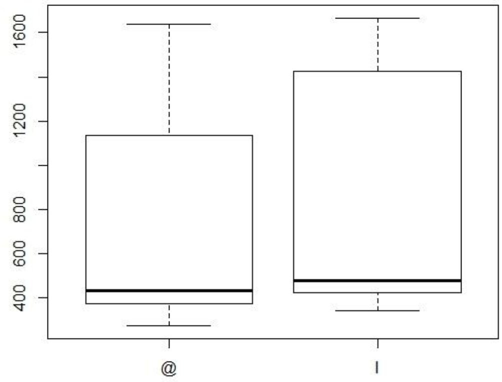
3.3 /ɪ - ə/

Male

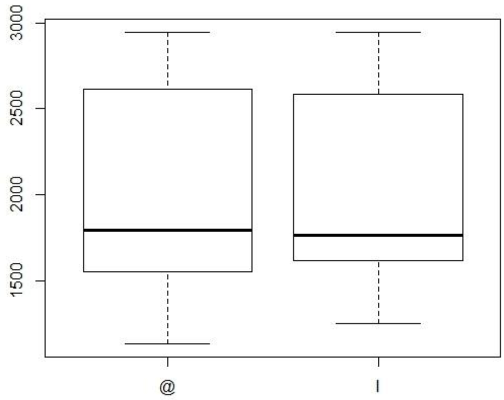
Duration (ms)



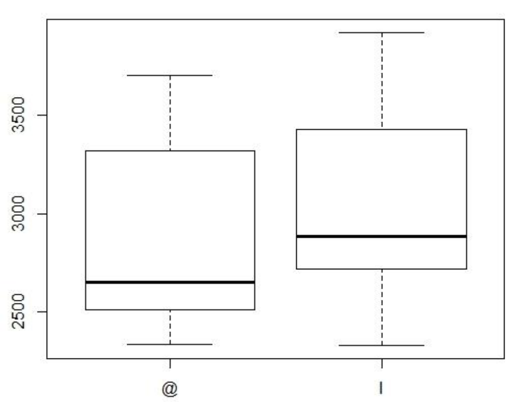
F1 (Hz)



F2 (Hz)

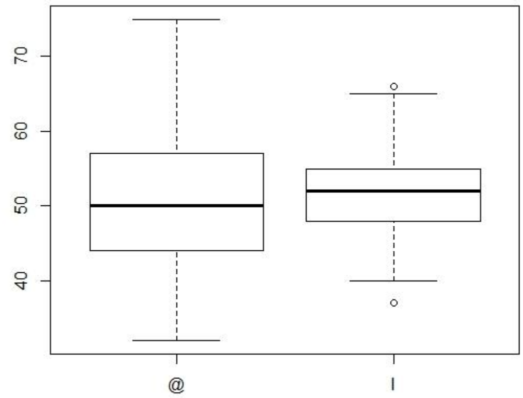


F3 (Hz)

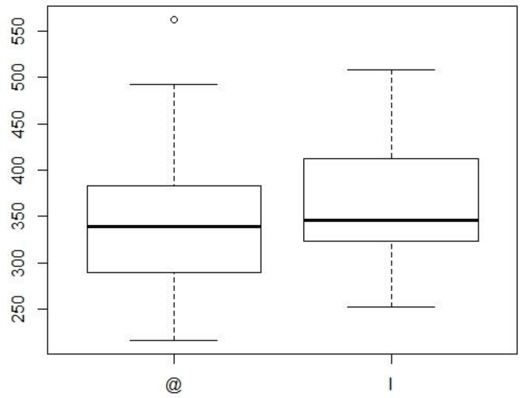


Female

Duration (ms)



F1 (Hz)



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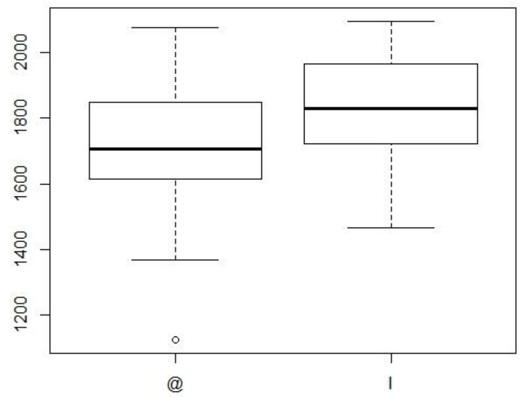
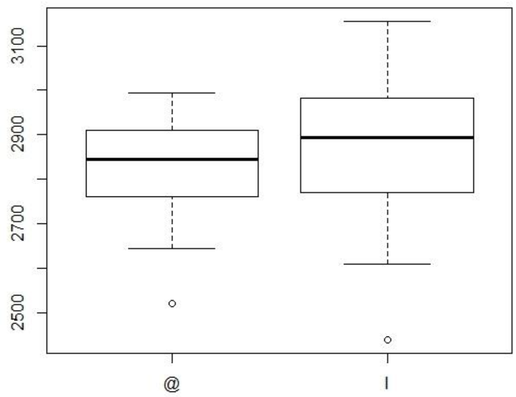


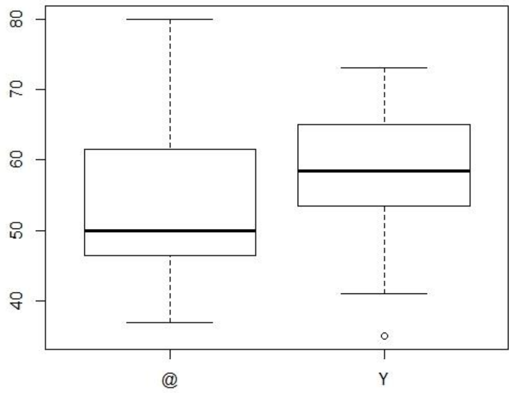
F3 (Hz)



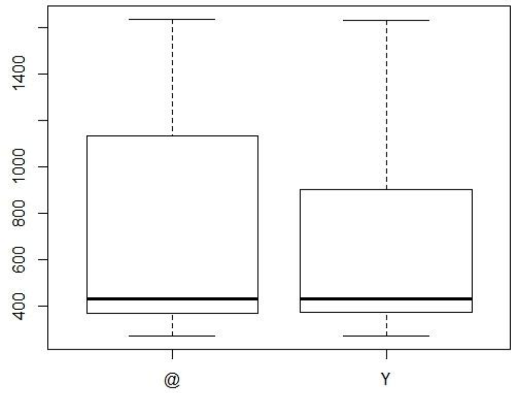
3.4 /ʏ - ə/

Male

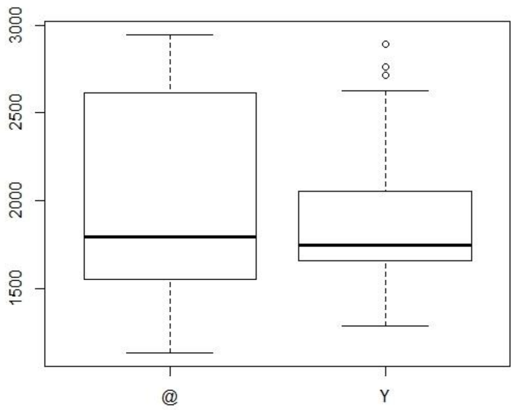
Duration (ms)



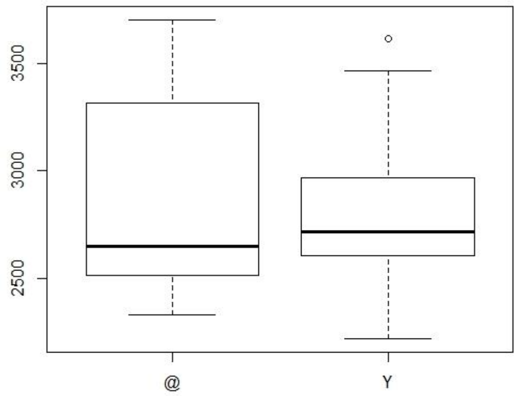
F1 (Hz)



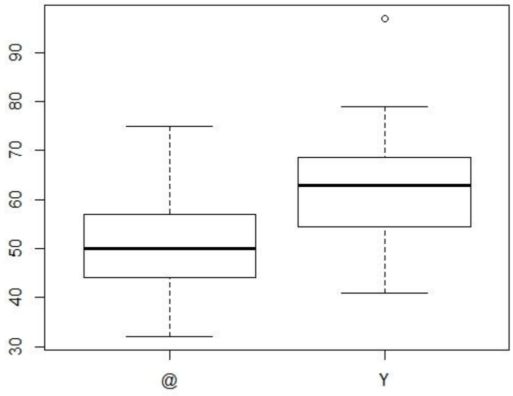
F2 (Hz)

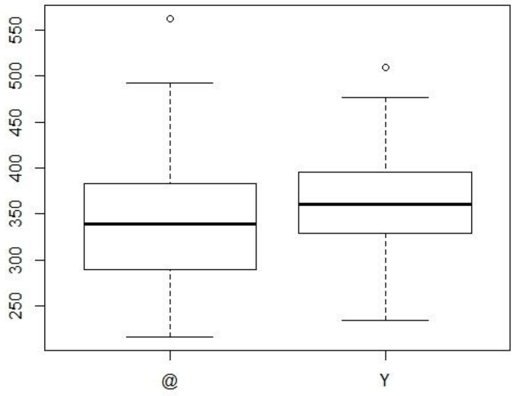


F3 (Hz)

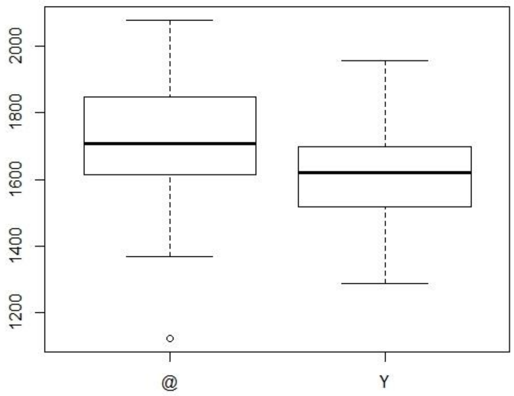


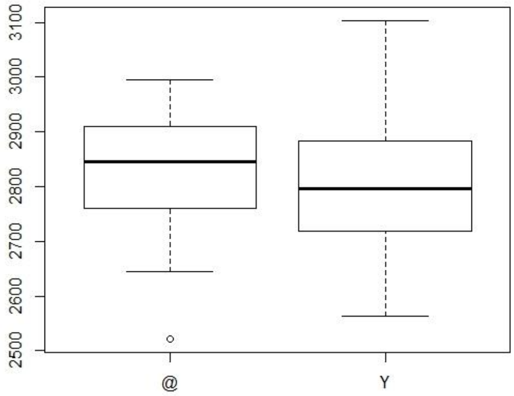
Female	
Duration (ms)	F1 (Hz)





F2 (Hz)	F3 (Hz)





3.5 /e - ø/

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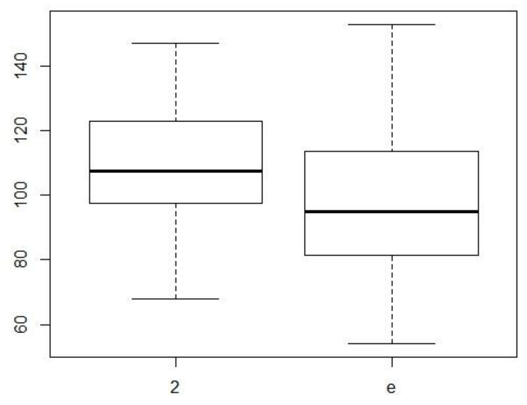
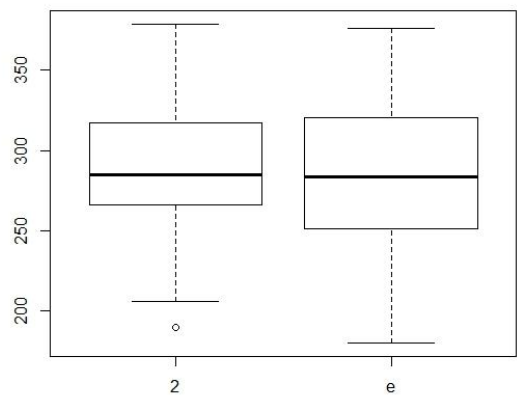
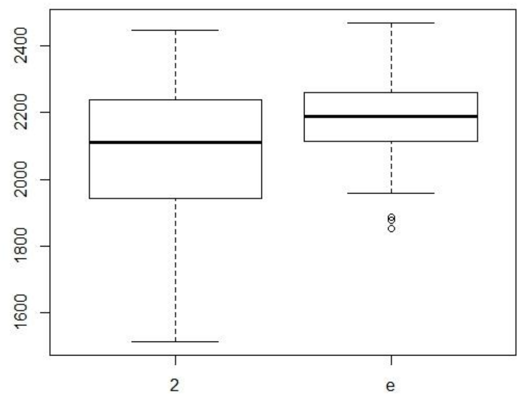
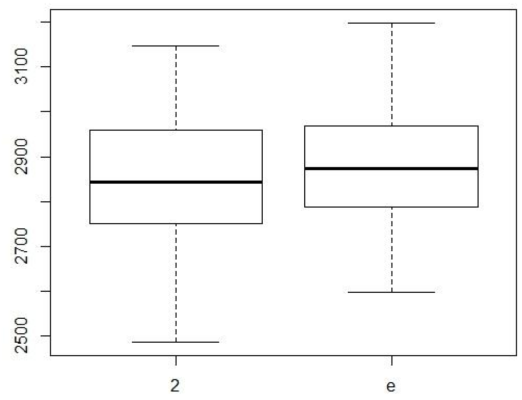
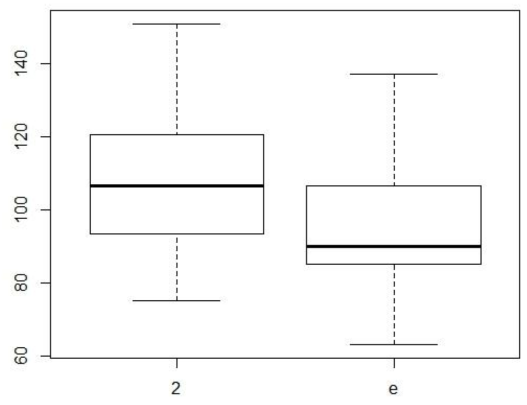
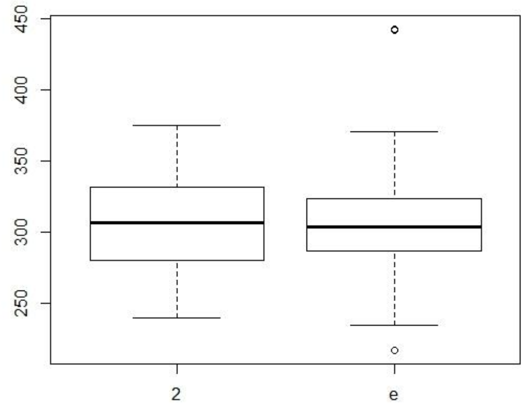
<tr><th>Duration (ms)</th><th>F1 (Hz)</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><th>F2 (Hz)</th><th>F3 (Hz)</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Female

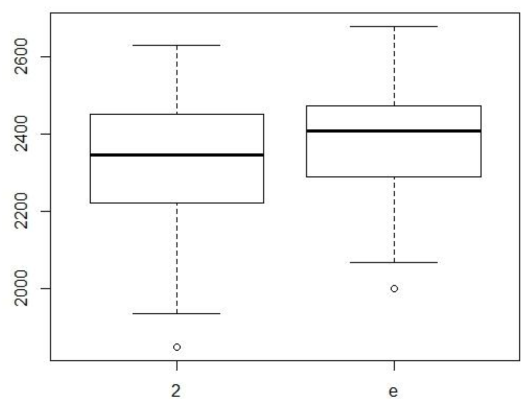
Duration (ms)



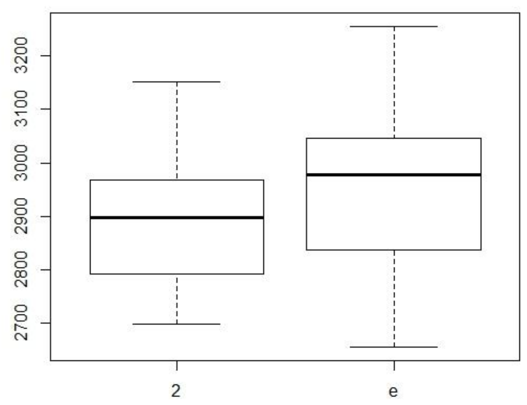
F1 (Hz)



F2 (Hz)



F3 (Hz)



Appendix D. ANOVA and Tukey's HSD test results

- This appendix presents RStudio screenshots of the ANOVAs and Tukey's HSD test results. The relevant p-values are indicated by a green frame.
  - **H_0**: there is no significant difference in means between variety A and variety B for the distance between the feature values of the two vowels
  - **H_A**: there is a significant difference in means between variety A and variety B for the distance between the feature values of the two vowels

1 /i - y/

Male

Duration (ms)

```
> summary(dur.aov)
               Df Sum Sq Mean Sq F value Pr(>F)
data$Language   2   2359  1179.6   1.993  0.141
Residuals     117  69245   591.8
> TukeyHSD(dur.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$Dur.diff ~ data$Language)

$`data$Language`
          diff        lwr      upr     p adj
NSD-AFR  -7.35 -20.26366 5.563658 0.3700135
SSD-AFR -10.60 -23.51366 2.313658 0.1298140
SSD-NSD  -3.25 -16.16366 9.663658 0.8217553
```

F1 (Hz)

```
> summary(F1.aov)
               Df Sum Sq Mean Sq F value Pr(>F)
data$Language   2   2514  1257.0   1.496  0.228
Residuals     117  98303   840.2
> TukeyHSD(F1.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F1.diff ~ data$Language)

$`data$Language`
         diff        lwr      upr     p adj
NSD-AFR  2.45 -12.936483 17.83648 0.9243183
SSD-AFR 10.70  -4.686483 26.08648 0.2286646
SSD-NSD  8.25  -7.136483 23.63648 0.4133192
```

Male

F2 (Hz)

```
> summary(F2.aov)
                 Df  Sum Sq Mean Sq F value   Pr(>F)    
data$Language     2 2512468 1256234   44.75 3.68e-15 ***
Residuals       117 3284536   28073                     
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F2.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F2.diff ~ data$Language)

$`data$Language`
          diff       lwr       upr    p adj
NSD-AFR 319.10  230.1607 408.03928 0.000000
SSD-AFR 293.15  204.2107 382.08928 0.000000
SSD-NSD -25.95 -114.8893  62.98928 0.768253
```

F3 (Hz)

```
> summary(F3.aov)
                 Df  Sum Sq Mean Sq F value Pr(>F)  
data$Language     2  265330  132665   2.667 0.0737 .
Residuals       117 5820846   49751                 
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F3.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F3.diff ~ data$Language)

$`data$Language`
           diff        lwr      upr     p adj
NSD-AFR  54.475 -63.924439 172.8744 0.5207856
SSD-AFR 115.125  -3.274439 233.5244 0.0585624
SSD-NSD  60.650 -57.749439 179.0494 0.4461191
```

Female
Duration (ms)

```
> summary(dur.aov)
                Df Sum Sq Mean Sq F value Pr(>F)
data$Language    2    252   125.8   0.241  0.786
Residuals      117  61106   522.3
> TukeyHSD(dur.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$Dur.diff ~ data$Language)

$`data$Language`
          diff        lwr      upr     p adj
NSD-AFR -0.825 -12.956008 11.30601 0.9857354
SSD-AFR  2.575  -9.556008 14.70601 0.8695773
SSD-NSD  3.400  -8.731008 15.53101 0.7840148
```

F1 (Hz)

```
> summary(F1.aov)
                Df Sum Sq Mean Sq F value Pr(>F)
data$Language    2   5655  2827.4   4.107 0.0189 *
Residuals      117  80540   688.4
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> TukeyHSD(F1.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F1.diff ~ data$Language)

$`data$Language`
          diff        lwr       upr     p adj
NSD-AFR -16.55 -30.477148 -2.622852 0.0154204
SSD-AFR -10.85 -24.777148  3.077148 0.1582617
SSD-NSD   5.70  -8.227148 19.627148 0.5962429
```

Female

F2 (Hz)

```
> summary(F2.aov)
                 Df  Sum Sq Mean Sq F value Pr(>F)    
data$Language     2 5871094 2935547   118.5 <2e-16 ***
Residuals       117 2898269   24772                   
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F2.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F2.diff ~ data$Language)

$`data$Language`
            diff      lwr       upr     p adj
NSD-AFR  520.225  436.679 603.77105 0.0000000
SSD-AFR  391.225  307.679 474.77105 0.0000000
SSD-NSD -129.000 -212.546 -45.45395 0.0010784
```

F3 (Hz)

```
> summary(F3.aov)
                 Df  Sum Sq Mean Sq F value   Pr(>F)    
data$Language     2 3157499 1578749   32.71 5.19e-12 ***
Residuals       117 5646512   48261                     
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F3.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F3.diff ~ data$Language)

$`data$Language`
           diff       lwr      upr     p adj
NSD-AFR 253.250 136.63707 369.8629 0.0000031
SSD-AFR 391.775 275.16207 508.3879 0.0000000
SSD-NSD 138.525  21.91207 255.1379 0.0154640
```

2 /ɪ - ʏ/

Male
Duration (ms)

```
> summary(dur.aov)
                 Df Sum Sq Mean Sq F value Pr(>F)
data$Language     2    220  110.03   1.317  0.272
Residuals       117   9772   83.52
> TukeyHSD(dur.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$Dur.diff ~ data$Language)

$`data$Language`
          diff       lwr      upr     p adj
NSD-AFR  3.150 -1.701209 8.001209 0.2754609
SSD-AFR  2.475 -2.376209 7.326209 0.4490002
SSD-NSD -0.675 -5.526209 4.176209 0.9416641
```

F1 (Hz)

```
> summary(F1.aov)
                 Df  Sum Sq Mean Sq F value  Pr(>F)
data$Language     2  253965  126983   6.177 0.00282 **
Residuals       117 2405166   20557
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> TukeyHSD(F1.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F1.diff ~ data$Language)

$`data$Language`
          diff        lwr       upr     p adj
NSD-AFR -99.375 -175.48278 -23.26722 0.0068094
SSD-AFR -95.700 -171.80778 -19.59222 0.0096029
SSD-NSD   3.675  -72.43278  79.78278 0.9927825
```

Male
F2 (Hz)

```
> summary(F2.aov)
                 Df  Sum Sq Mean Sq F value  Pr(>F)
data$Language   2  661271  330636   6.791 0.00162 **
Residuals     117 5696090   48685
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> TukeyHSD(F2.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F2.diff ~ data$Language)

$`data$Language`
           diff        lwr      upr     p adj
NSD-AFR 121.075   3.951246 238.1988 0.0410179
SSD-AFR 178.025  60.901246 295.1488 0.0013130
SSD-NSD  56.950 -60.173754 174.0738 0.4828805
```

F3 (Hz)

```
> summary(F3.aov)
                 Df  Sum Sq Mean Sq F value  Pr(>F)
data$Language   2  335459  167730   4.904 0.00901 **
Residuals     117 4001466   34201
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> TukeyHSD(F3.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F3.diff ~ data$Language)

$`data$Language`
            diff       lwr        upr     p adj
NSD-AFR  -96.075 -194.2421   2.092146 0.0564963
SSD-AFR -123.250 -221.4171 -25.082854 0.0097327
SSD-NSD  -27.175 -125.3421  70.992146 0.7886823
```

Female
Duration (ms)

```
> summary(dur.aov)
                Df Sum Sq Mean Sq F value Pr(>F)
data$Language    2    367   183.5   1.525  0.222
Residuals      117  14078   120.3
> TukeyHSD(dur.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$Dur.diff ~ data$Language)

$`data$Language`
          diff       lwr       upr     p adj
NSD-AFR  4.275 -1.547828 10.097828 0.1937348
SSD-AFR  2.375 -3.447828  8.197828 0.5983319
SSD-NSD -1.900 -7.722828  3.922828 0.7193122
```

F1 (Hz)

```
> summary(F1.aov)
               Df Sum Sq Mean Sq F value Pr(>F)
data$Language   2  19725    9863   3.937 0.0221 *
Residuals     117 293113    2505
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F1.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F1.diff ~ data$Language)

$`data$Language`
           diff       lwr        upr     p adj
NSD-AFR -28.075 -54.64395 -1.5060544 0.0357332
SSD-AFR -26.225 -52.79395  0.3439456 0.0538657
SSD-NSD   1.850 -24.71895 28.4189456 0.9850519
```

Female
F2 (Hz)

```
> summary(F2.aov)
                 Df  Sum Sq Mean Sq F value   Pr(>F)    
data$Language     2 3707627 1853813   48.15 5.52e-16 ***
Residuals       117 4504335   38499                     
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F2.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F2.diff ~ data$Language)

$`data$Language`
           diff      lwr       upr     p adj
NSD-AFR 380.325  276.172 484.47803 0.0000000
SSD-AFR 364.950  260.797 469.10303 0.0000000
SSD-NSD -15.375 -119.528  88.77803 0.9345886
```

F3 (Hz)

```
> summary(F3.aov)
                 Df  Sum Sq Mean Sq F value   Pr(>F)    
data$Language     2  877952  438976   20.71 1.99e-08 ***
Residuals       117 2479589   21193                     
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F3.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F3.diff ~ data$Language)

$`data$Language`
           diff       lwr      upr     p adj
NSD-AFR  40.575 -36.70132 117.8513 0.4284257
SSD-AFR 198.300 121.02368 275.5763 0.0000000
SSD-NSD 157.725  80.44868 235.0013 0.0000116
```

3 /ɪ - ə/

Male
Duration (ms)

```
> summary(dur.aov)
                Df Sum Sq Mean Sq F value Pr(>F)
data$Language    2    133   66.41   1.341  0.266
Residuals      117   5793   49.51
> TukeyHSD(dur.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$Dur.diff ~ data$Language)

$`data$Language`
         diff       lwr      upr     p adj
NSD-AFR 0.200 -3.535169 3.935169 0.9911326
SSD-AFR 2.325 -1.410169 6.060169 0.3053377
SSD-NSD 2.125 -1.610169 5.860169 0.3703304
```

F1 (Hz)

```
> summary(F1.aov)
                Df  Sum Sq Mean Sq F value  Pr(>F)
data$Language    2  222611  111305   5.186 0.00695 **
Residuals      117 2511231   21464
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> TukeyHSD(F1.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F1.diff ~ data$Language)

$`data$Language`
            diff       lwr          upr     p adj
NSD-AFR  -77.825 -155.5928  -0.05718672 0.0497877
SSD-AFR -100.600 -178.3678 -22.83218672 0.0074303
SSD-NSD  -22.775 -100.5428  54.99281328 0.7667477
```

Male
F2 (Hz)

```
> summary(F2.aov)
                 Df  Sum Sq Mean Sq F value Pr(>F)
data$Language     2  447377  223689   3.477 0.0341 *
Residuals       117 7527786   64340
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F2.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F2.diff ~ data$Language)

$`data$Language`
           diff         lwr     upr     p adj
NSD-AFR 121.825  -12.819996 256.470 0.0847598
SSD-AFR 136.050    1.405004 270.695 0.0470580
SSD-NSD  14.225 -120.419996 148.870 0.9659301
```

F3 (Hz)

```
> summary(F3.aov)
                 Df  Sum Sq Mean Sq F value  Pr(>F)
data$Language     2  614516  307258   5.181 0.00699 **
Residuals       117 6939272   59310
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F3.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F3.diff ~ data$Language)

$`data$Language`
            diff       lwr      upr     p adj
NSD-AFR -110.825 -240.0997  18.4497 0.1083765
SSD-AFR -173.025 -302.2997 -43.7503 0.0053632
SSD-NSD  -62.200 -191.4747  67.0747 0.4901955
```

Female

Duration (ms)

```
> summary(dur.aov)
                Df Sum Sq Mean Sq F value Pr(>F)
data$Language    2    100   50.11   0.766  0.467
Residuals      117   7651   65.39
> TukeyHSD(dur.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$Dur.diff ~ data$Language)

$`data$Language`
          diff      lwr     upr     p adj
NSD-AFR  0.900 -3.39249 5.19249 0.8725331
SSD-AFR -1.325 -5.61749 2.96749 0.7445619
SSD-NSD -2.225 -6.51749 2.06749 0.4376625
```

F1 (Hz)

```
> summary(F1.aov)
                Df Sum Sq Mean Sq F value Pr(>F)
data$Language    2  24578   12289   3.952 0.0218 *
Residuals      117 363826    3110
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F1.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F1.diff ~ data$Language)

$`data$Language`
           diff       lwr       upr     p adj
NSD-AFR -34.975 -64.57582 -5.374181 0.0161339
SSD-AFR -19.550 -49.15082 10.050819 0.2636370
SSD-NSD  15.425 -14.17582 45.025819 0.4338661
```

Female
F2 (Hz)

```
> summary(F2.aov)
                 Df  Sum Sq Mean Sq F value Pr(>F)    
data$Language     2 4454656 2227328   63.09 <2e-16 ***
Residuals       117 4130687   35305                   
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F2.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F2.diff ~ data$Language)

$`data$Language`
          diff       lwr       upr    p adj
NSD-AFR 419.80  320.0604 519.53962 0.000000
SSD-AFR 396.65  296.9104 496.38962 0.000000
SSD-NSD -23.15 -122.8896  76.58962 0.846171
```

F3 (Hz)

```
> summary(F3.aov)
                 Df  Sum Sq Mean Sq F value Pr(>F)
data$Language     2    2437    1219    0.09  0.914
Residuals       117 1580958   13512               
> TukeyHSD(F3.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F3.diff ~ data$Language)

$`data$Language`
        diff       lwr      upr     p adj
NSD-AFR -0.5 -62.20448 61.20448 0.9997960
SSD-AFR  9.3 -52.40448 71.00448 0.9319123
SSD-NSD  9.8 -51.90448 71.50448 0.9246914
```

4 /ɤ - ə/

Male
Duration (ms)

```
> summary(dur.aov)
                 Df Sum Sq Mean Sq F value Pr(>F)  
data$Language    2    509  254.63    3.59 0.0307 *
Residuals      117   8299   70.93                 
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(dur.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$Dur.diff ~ data$Language)

$`data$Language`
         diff       lwr      upr     p adj
NSD-AFR  4.75  0.279275 9.220725 0.0344985
SSD-AFR  0.90 -3.570725 5.370725 0.8818654
SSD-NSD -3.85 -8.320725 0.620725 0.1062726
```

F1 (Hz)

```
> summary(F1.aov)
                 Df Sum Sq Mean Sq F value Pr(>F)  
data$Language    2  42162   21081   3.639 0.0293 *
Residuals      117 677831    5793                 
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F1.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F1.diff ~ data$Language)

$`data$Language`
           diff       lwr       upr     p adj
NSD-AFR -33.300 -73.70334  7.103335 0.1277140
SSD-AFR -44.025 -84.42834 -3.621665 0.0291808
SSD-NSD -10.725 -51.12834 29.678335 0.8038568
```

Male
F2 (Hz)

```
> summary(F2.aov)
                 Df  Sum Sq Mean Sq F value Pr(>F)
data$Language     2   59161   29580   0.872  0.421
Residuals       117 3968559   33919
> TukeyHSD(F2.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F2.diff ~ data$Language)

$`data$Language`
           diff       lwr      upr     p adj
NSD-AFR  -7.300 -105.0627 90.46266 0.9828292
SSD-AFR -50.325 -148.0877 47.43766 0.4426192
SSD-NSD -43.025 -140.7877 54.73766 0.5502741
```

F3 (Hz)

```
> summary(F3.aov)
                 Df  Sum Sq Mean Sq F value Pr(>F)
data$Language     2  173485   86743   2.719 0.0701 .
Residuals       117 3732229   31899
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F3.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F3.diff ~ data$Language)

$`data$Language`
         diff        lwr       upr     p adj
NSD-AFR  81.3  -13.50706 176.10706 0.1082408
SSD-AFR   1.3  -93.50706  96.10706 0.9994160
SSD-NSD -80.0 -174.80706  14.80706 0.1159445
```

Female

Duration (ms)

```
> summary(dur.aov)
               Df Sum Sq Mean Sq F value Pr(>F)
data$Language   2    327   163.6   1.497  0.228
Residuals     117  12784   109.3
> TukeyHSD(dur.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$Dur.diff ~ data$Language)

$`data$Language`
          diff       lwr      upr     p adj
NSD-AFR  0.375 -5.173635 5.923635 0.9859111
SSD-AFR -3.300 -8.848635 2.248635 0.3381125
SSD-NSD -3.675 -9.223635 1.873635 0.2616828
```

F1 (Hz)

```
> summary(F1.aov)
               Df Sum Sq Mean Sq F value Pr(>F)
data$Language   2   3689    1844   0.815  0.445
Residuals     117 264921    2264
> TukeyHSD(F1.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F1.diff ~ data$Language)

$`data$Language`
           diff       lwr      upr     p adj
NSD-AFR -12.750 -38.00892 12.50892 0.4565754
SSD-AFR -10.425 -35.68392 14.83392 0.5910749
SSD-NSD   2.325 -22.93392 27.58392 0.9740276
```

Female
F2 (Hz)

```
> summary(F2.aov)
                 Df  Sum Sq Mean Sq F value Pr(>F)
data$Language     2  114891   57446    3.99 0.0211 *
Residuals       117 1684659   14399
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> TukeyHSD(F2.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F2.diff ~ data$Language)

$`data$Language`
           diff        lwr       upr     p adj
NSD-AFR -52.475 -116.17105 11.221053 0.1279351
SSD-AFR -73.600 -137.29605 -9.903947 0.0191642
SSD-NSD -21.125  -84.82105 42.571053 0.7115505
```

F3 (Hz)

```
> summary(F3.aov)
                 Df  Sum Sq Mean Sq F value   Pr(>F)
data$Language     2  620361  310181   20.62 2.14e-08 ***
Residuals       117 1760235   15045
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> TukeyHSD(F3.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F3.diff ~ data$Language)

$`data$Language`
           diff       lwr      upr     p adj
NSD-AFR 125.125  60.01587 190.2341 0.0000372
SSD-AFR 169.900 104.79087 235.0091 0.0000000
SSD-NSD  44.775 -20.33413 109.8841 0.2361078
```

5 /e - ø/

Male
Duration (ms)

```
> summary(dur.aov)
                 Df Sum Sq Mean Sq F value Pr(>F)
data$Language     2    128    64.1   0.178  0.837
Residuals       117  42083   359.7
> TukeyHSD(dur.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$Dur.diff ~ data$Language)

$`data$Language`
          diff       lwr      upr     p adj
NSD-AFR -0.775 -10.84227 9.292273 0.9817598
SSD-AFR -2.475 -12.54227 7.592273 0.8291530
SSD-NSD -1.700 -11.76727 8.367273 0.9153045
```

F1 (Hz)

```
> summary(F1.aov)
                 Df Sum Sq Mean Sq F value  Pr(>F)
data$Language     2  89255   44628   6.652 0.00184 **
Residuals       117 784951    6709
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F1.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F1.diff ~ data$Language)

$`data$Language`
           diff         lwr       upr     p adj
NSD-AFR  48.525    5.046171  92.00383 0.0247119
SSD-AFR -15.500  -58.978829  27.97883 0.6750672
SSD-NSD -64.025 -107.503829 -20.54617 0.0019212
```

Male

F2 (Hz)

```
> summary(F2.aov)
               Df  Sum Sq Mean Sq F value   Pr(>F)    
data$Language   2 1630218  815109   20.89 1.75e-08 ***
Residuals     117 4564965   39017                     
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F2.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F2.diff ~ data$Language)

$`data$Language`
           diff       lwr      upr     p adj
NSD-AFR  74.275 -30.57666 179.1267 0.2165318
SSD-AFR 275.875 171.02334 380.7267 0.0000000
SSD-NSD 201.600  96.74834 306.4517 0.0000369
```

F3 (Hz)

```
> summary(F3.aov)
               Df  Sum Sq Mean Sq F value   Pr(>F)    
data$Language   2  409818  204909    7.81 0.000655 ***
Residuals     117 3069612   26236                     
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F3.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F3.diff ~ data$Language)

$`data$Language`
           diff       lwr      upr     p adj
NSD-AFR 107.725  21.74482 193.7052 0.0099118
SSD-AFR 135.500  49.51982 221.4802 0.0008282
SSD-NSD  27.775 -58.20518 113.7552 0.7240238
```

Female
Duration (ms)

```
> summary(dur.aov)
                 Df Sum Sq Mean Sq F value Pr(>F)
data$Language    2    103   51.73   0.188  0.829
Residuals      117  32226  275.44
> TukeyHSD(dur.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$Dur.diff ~ data$Language)

$`data$Language`
        diff        lwr      upr     p adj
NSD-AFR -0.6  -9.409727 8.209727 0.9856941
SSD-AFR -2.2 -11.009727 6.609727 0.8242402
SSD-NSD -1.6 -10.409727 7.209727 0.9027105
```

F1 (Hz)

```
> summary(F1.aov)
                 Df Sum Sq Mean Sq F value   Pr(>F)
data$Language    2  29657   14829   7.706 0.000718 ***
Residuals      117 225133    1924
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F1.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F1.diff ~ data$Language)

$`data$Language`
          diff       lwr       upr     p adj
NSD-AFR  35.25  11.96501 58.534991 0.0013798
SSD-AFR   4.20 -19.08499 27.484991 0.9039710
SSD-NSD -31.05 -54.33499 -7.765009 0.0055622
```

Female
F2 (Hz)

```
> summary(F2.aov)
                Df  Sum Sq Mean Sq F value Pr(>F)    
data$Language    2 8564234 4282117   147.6 <2e-16 ***
Residuals      117 3394764   29015                   
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F2.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F2.diff ~ data$Language)

$`data$Language`
           diff       lwr      upr     p adj
NSD-AFR 534.075 443.65565 624.4943 0.0000000
SSD-AFR 594.500 504.08065 684.9193 0.0000000
SSD-NSD  60.425 -29.99435 150.8443 0.2555285
```

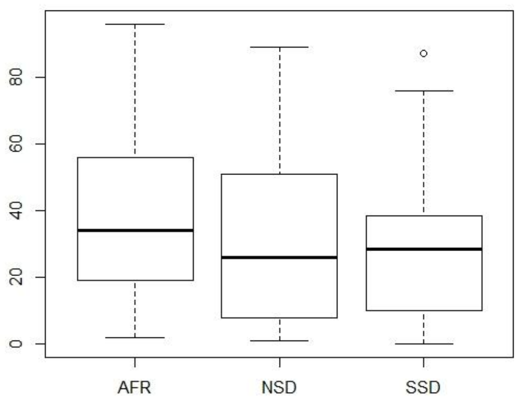
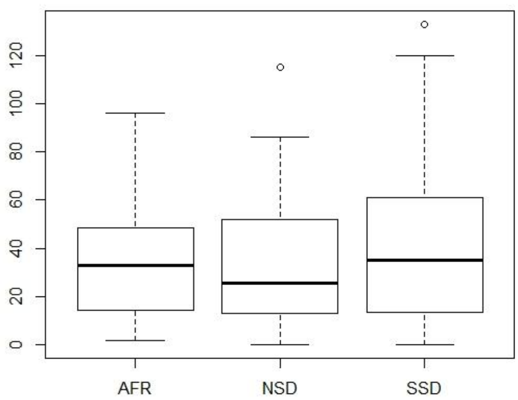
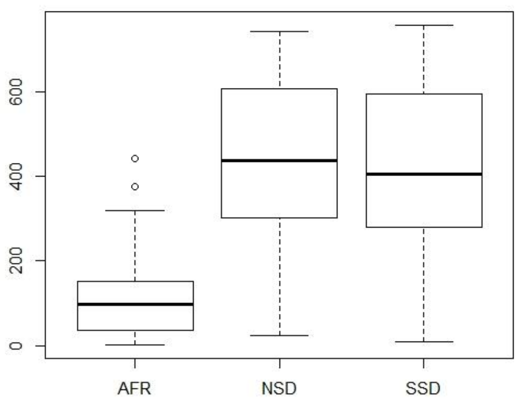
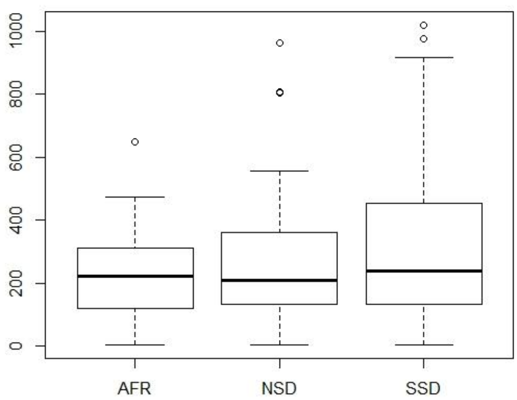
F3 (Hz)

```
> summary(F3.aov)
                Df  Sum Sq Mean Sq F value Pr(>F)    
data$Language    2 3081003 1540501   120.1 <2e-16 ***
Residuals      117 1501335   12832                   
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(F3.aov)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = data$F3.diff ~ data$Language)

$`data$Language`
           diff       lwr      upr    p adj
NSD-AFR 121.675  61.54442 181.8056 1.38e-05
SSD-AFR 384.000 323.86942 444.1306 0.00e+00
SSD-NSD 262.325 202.19442 322.4556 0.00e+00
```

Appendix E. Cross-linguistic contrast differences (box plots)

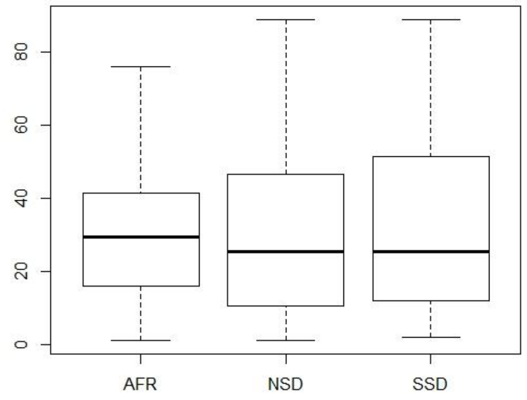
The following box plots visualize the distance between the two vowels in each vowel pair for each feature, and are thus a visualization of the data on which the Tukey's HSD tests (cf. Appendix D) are based.

1 /i - y/

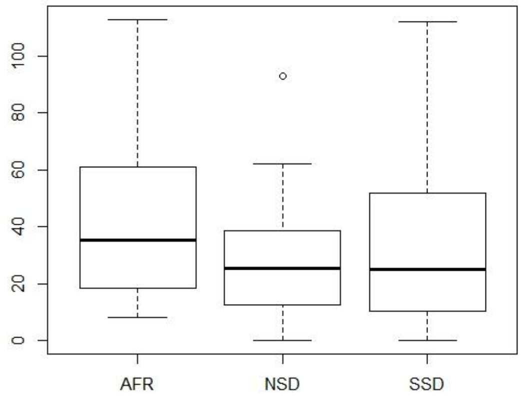
<table>
<tr><th colspan="2">Male</th></tr>
<tr><th>Duration (ms)</th><th>F1 (Hz)</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><th>F2 (Hz)</th><th>F3 (Hz)</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Female

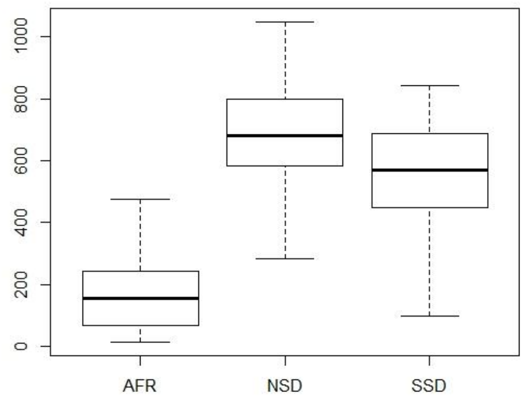
Duration (ms)



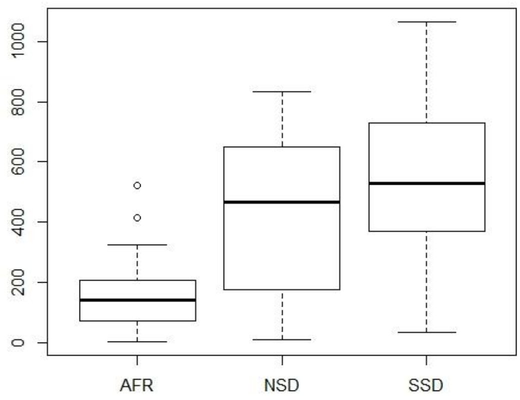
F1 (Hz)



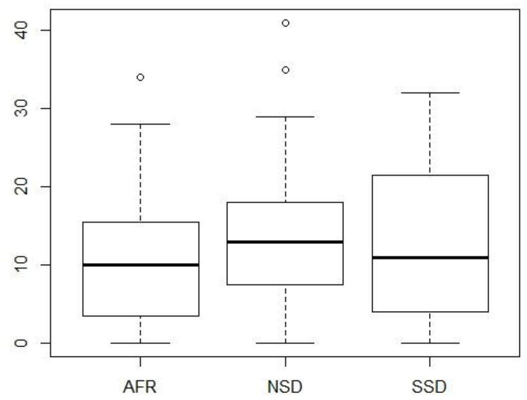
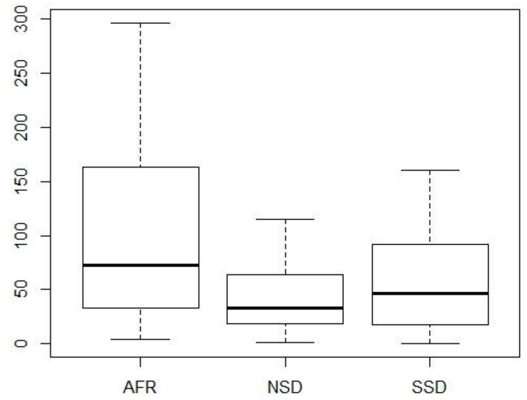
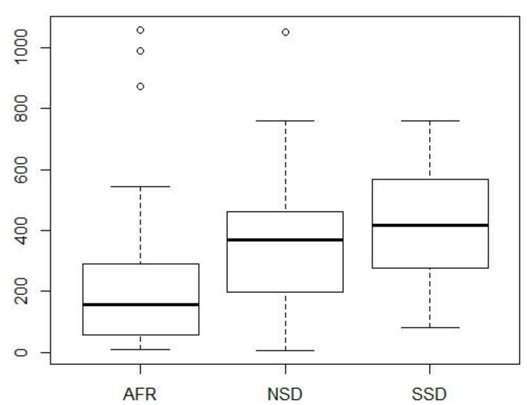
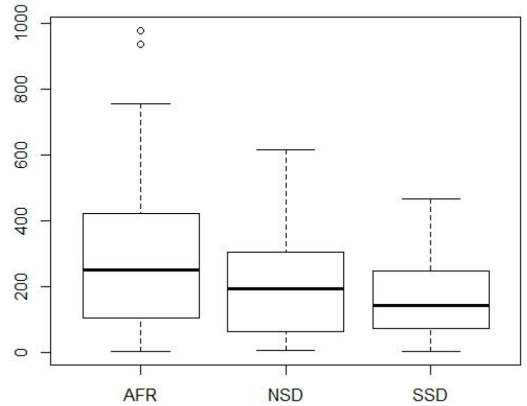
F2 (Hz)

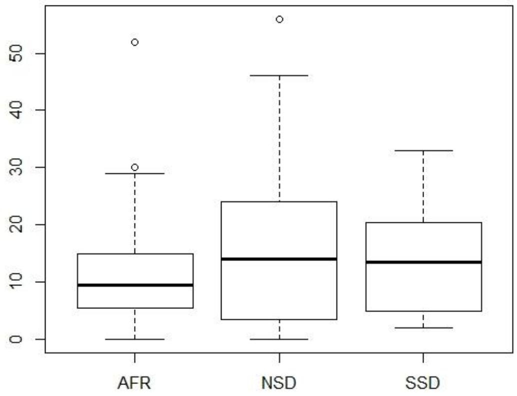
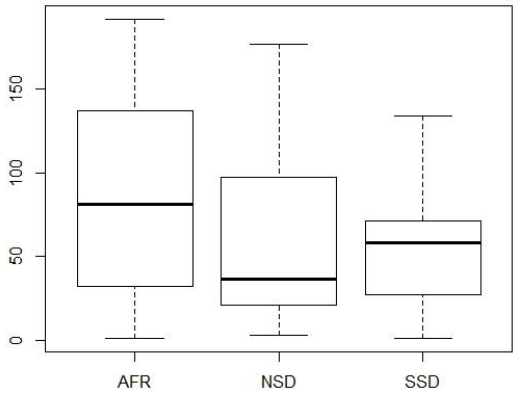
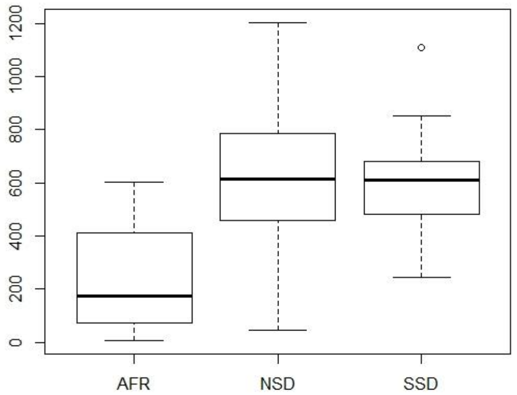
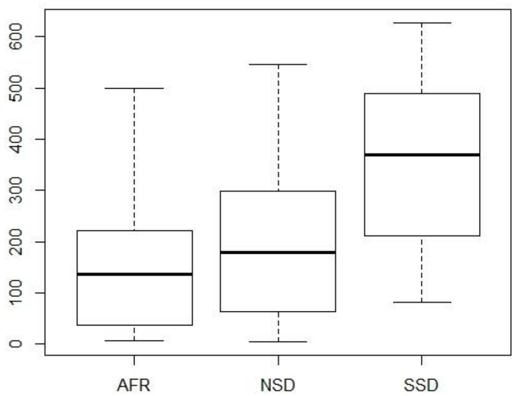


F3 (Hz)



2 /ɪ - ʏ/

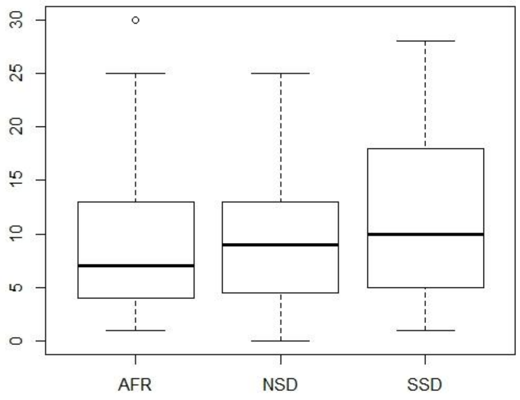
<table>
<tr><th colspan="2">Male</th></tr>
<tr><th>Duration (ms)</th><th>F1 (Hz)</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><th>F2 (Hz)</th><th>F3 (Hz)</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Female	
Duration (ms)	**F1 (Hz)**
	
F2 (Hz)	**F3 (Hz)**
	

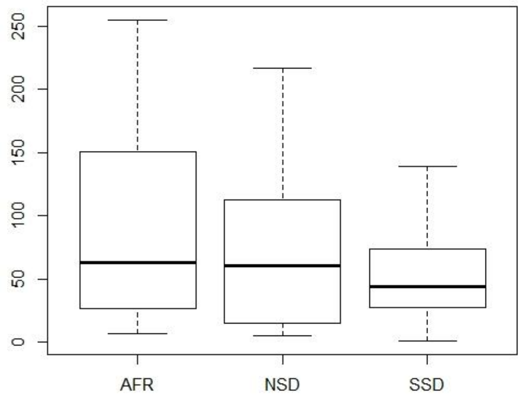
3 /ɪ - ə/

Male

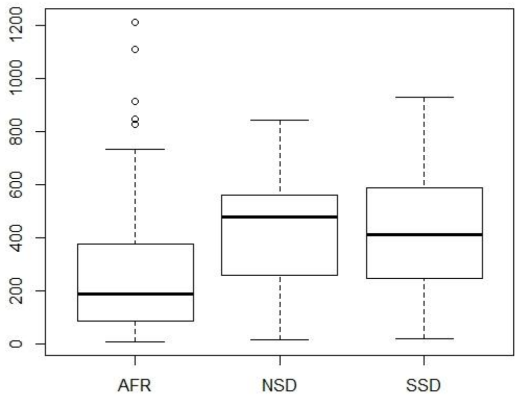
Duration (ms)



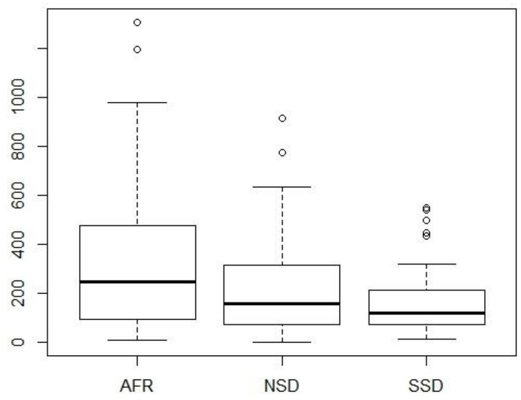
F1 (Hz)



F2 (Hz)

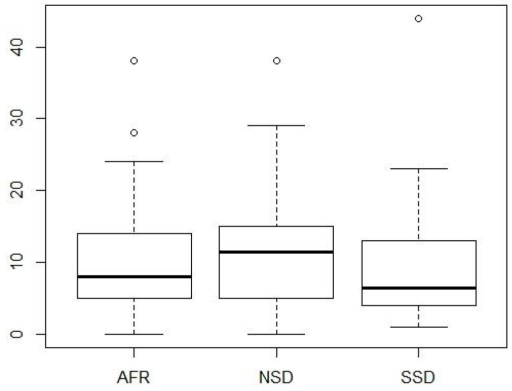


F3 (Hz)

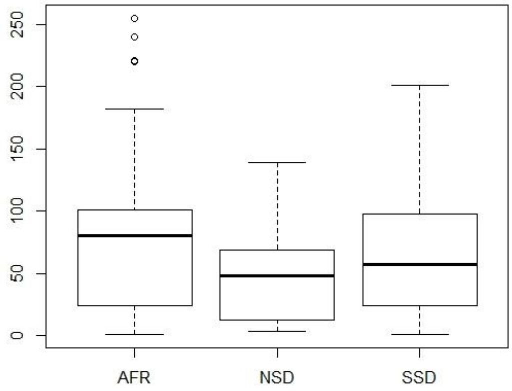


Female

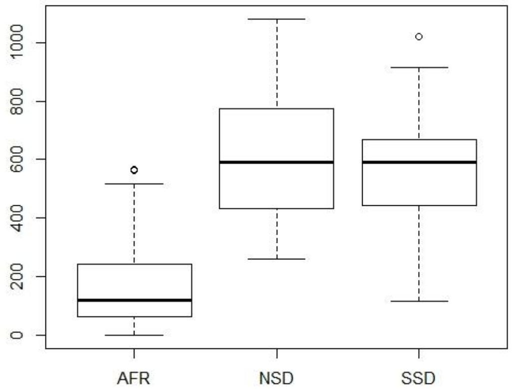
Duration (ms)



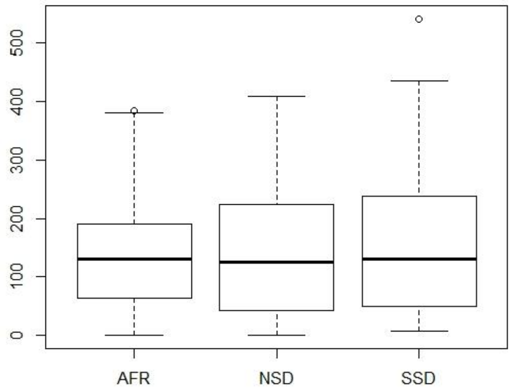
F1 (Hz)



F2 (Hz)



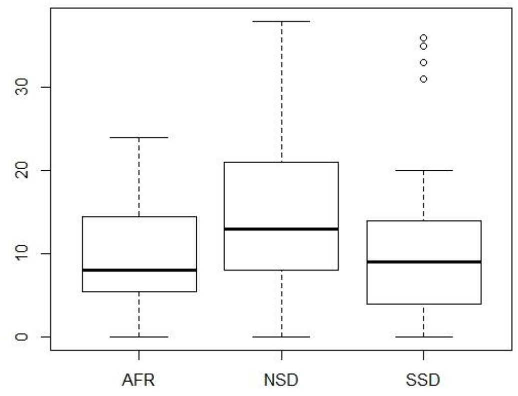
F3 (Hz)



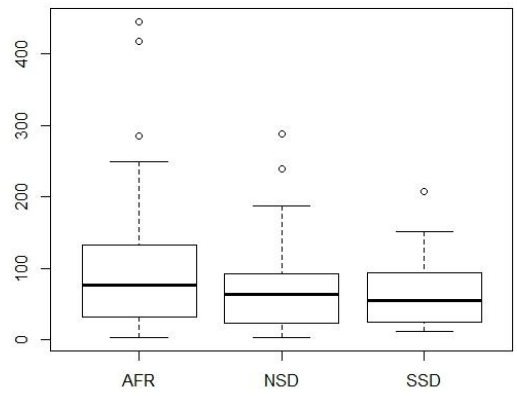
4 /ɤ - ə/

Male

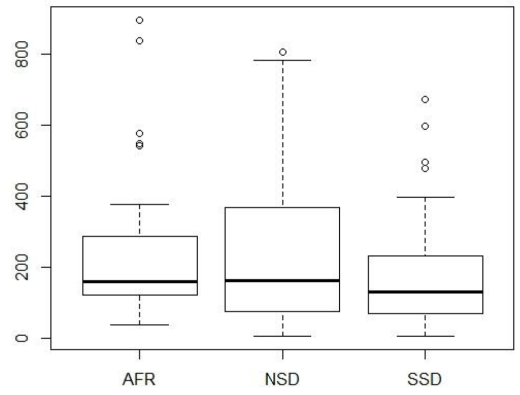
Duration (ms)



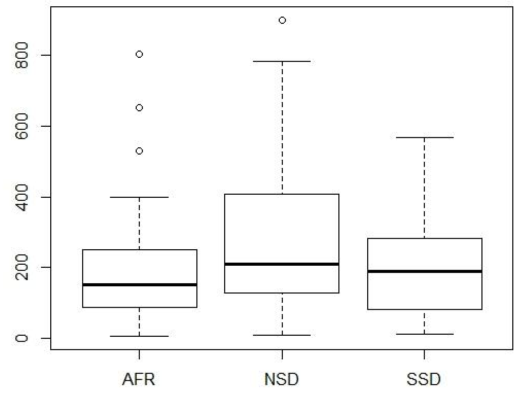
F1 (Hz)

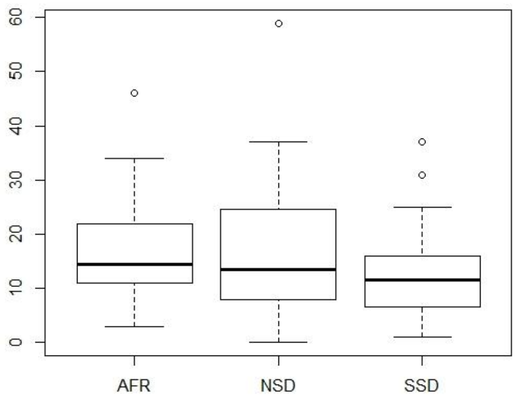
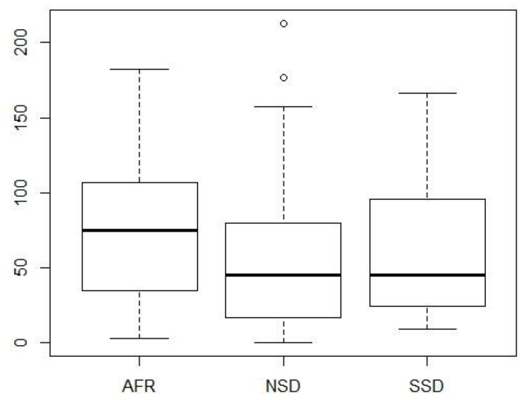
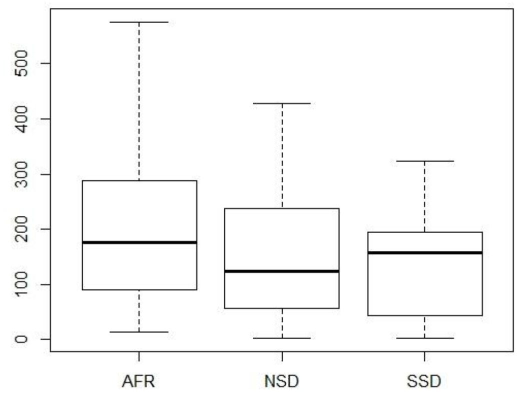
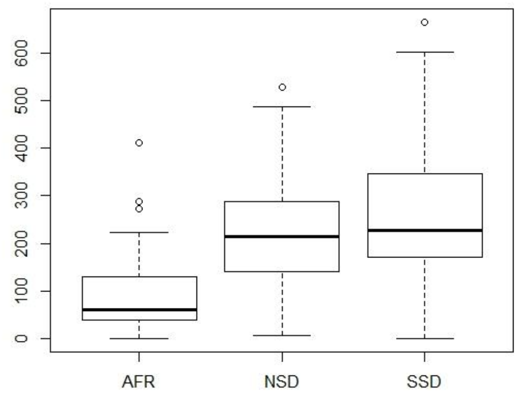


F2 (Hz)

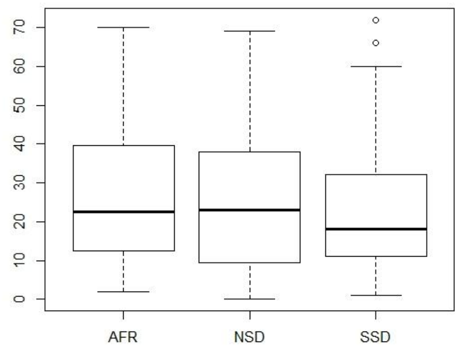
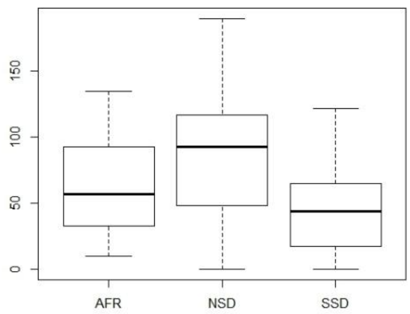
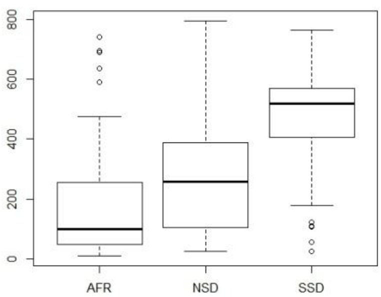
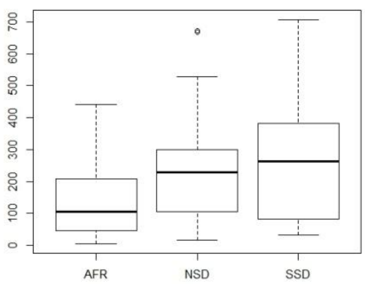


F3 (Hz)



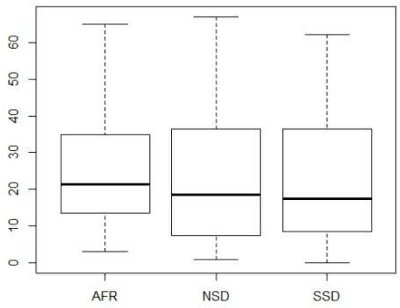
Female	
Duration (ms)	F1 (Hz)
	
F2 (Hz)	F3 (Hz)
	

5 /e – ø/

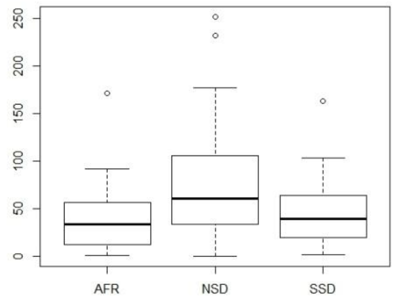
Male	
Duration (ms)	**F1 (Hz)**
	
F2 (Hz)	**F3 (Hz)**
	

Female

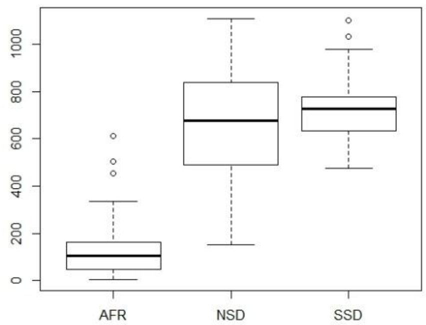
Duration (ms)



F1 (Hz)



F2 (Hz)



F3 (Hz)