Ruhr Universität Bochum
Sprachwissenschaftliches Institut

'An approach to analysing distinctive native language phonetic features by non-native language data'

Term paper for the course 'Phonetik'
summer term 2006
Dr. Martin Hoelter

submitted by

Björn Wilmsmann
Stefan-George-Str. 15a
46117 Oberhausen
bjoern@wilmsmann.de

on 30 August 2006

Table of Contents

Usually, natural language data in linguistics is used for analysing distinctive features of a specific language or for exemplifying assertions made about either the structure of a single language or language in general.
However, given the fact that speakers tend to transfer features of their mother-tongue to other non-natively acquired languages, it should be possible to derive a set of distinctive properties for a given language without actually disposing of data from that language, but rather by comparing native to non-native samples.
In this article we shall try to leverage this approach as for phonetic features of German and Spanish by comparing English samples uttered by speakers of these languages to counterparts uttered by speakers whose native tongue is a variety of the English language.
Furthermore, it will be shown that, using this method, it is not only possible to outline in how far the languages mentioned above are phonetically different from English, but also how the insights gained from this process might help us in recognising how these languages differ from one another regarding some of their phonetic traits.

1. Non-native language data as a source of native language phonetic features?

The usual way of analysing specific properties of a language is retrieving data from that language and examining these data according to frequently occurring patterns. This approach, however, might appear less suitable when it comes to comparing several languages or accents, that is if not only the mere features of a language, but also its distinctiveness in comparison to other languages is to be outlined.
In the following article we shall try to sketch some of the distinctive phonetic properties of both native English accents and German and Spanish ones alike.
This goal instead will be pursued by taking a text from one language, English in this case, and have speakers of each of the languages to be analysed utter this specimen. In doing so, we shall not gain information about the languages directly from native language data, but indirectly from 'speaking habits' which have been acquired through use of the native tongue and are transferred to non-native languages accordingly. This transfer of 'speaking habits' can for instance be observed in the tendency of non-native language speakers to replace phonemes that, to them, are difficult to pronounce with similar sounding phonemes of their respective native language (Arslan/Hansen, 1996: 357).

We shall put emphasis mainly on formant analysis as a means of phonetic analysis in order to obtain information about the properties of the treated speech excerpts, as this method has been shown to be one of the most pertinent for language accent discrimination (Arslan/Hansen, 1996: 360-361).

For the purpose of our examination we shall focus on the properties of the lower front vowel /æ/ (as in 'slab'), the word-internal voiced dental fricative /ð/ (as in 'brother') and the voiced alveolar approximant /ɹ/ (as in 'bring') from the English phoneme inventory.

First, we shall extract and underline the features of these phonemes in native English accents, using South-Eastern British, South-Eastern Irish and West Coast American English samples as a source.

Secondly, we shall deal with German and Spanish English accents respectively, underlining the features of the realisations of the same phonemes exposed in samples by native German and Spanish speakers.

Furthermore, it will be shown how the information acquired from analysis of the German and Spanish samples can be applied for underlining in how far native English accents differ from the languages mentioned above.

Afterwards, we shall attempt to summarise the aspects outlined in this work and discuss possible practical applications of accent classification via distinctive phonetic traits.

The speech samples used in terms of this work will be analysed according to their formant structure and the properties that can be derived from this. Using these properties, we shall try to draw conclusions regarding the occurrence and structure of specific phonemes.

For this purpose the speech analysis / synthesis software Praat (see section 'References' for more information) will be used. All figures and diagrams in this work have been created using Praat as well.

The speech samples used in this article are taken from the Speech Accent Archive (again, see section 'References' for more information). The speech samples in this archive sport speakers of English, both native and non-native, from around the world all uttering the same so-called elicitation paragraph (see appendix A under 6.1 for more information).

2. Phonetic analysis of native English accents

2.1 South-Eastern British English accent

In this section we shall outline the variations of the phonemes mentioned before in the South-Eastern British English accent. For this purpose a recording of a speaker from Littlehampton, West Sussex, UK[1] will be used.

First, we shall deal with the /ɹ/ phoneme as occurring in the word 'bring' in the elicitation paragraph. This word displays the formant structure illustrated by figure 1.), the light yellow background denotes the period of time in question:

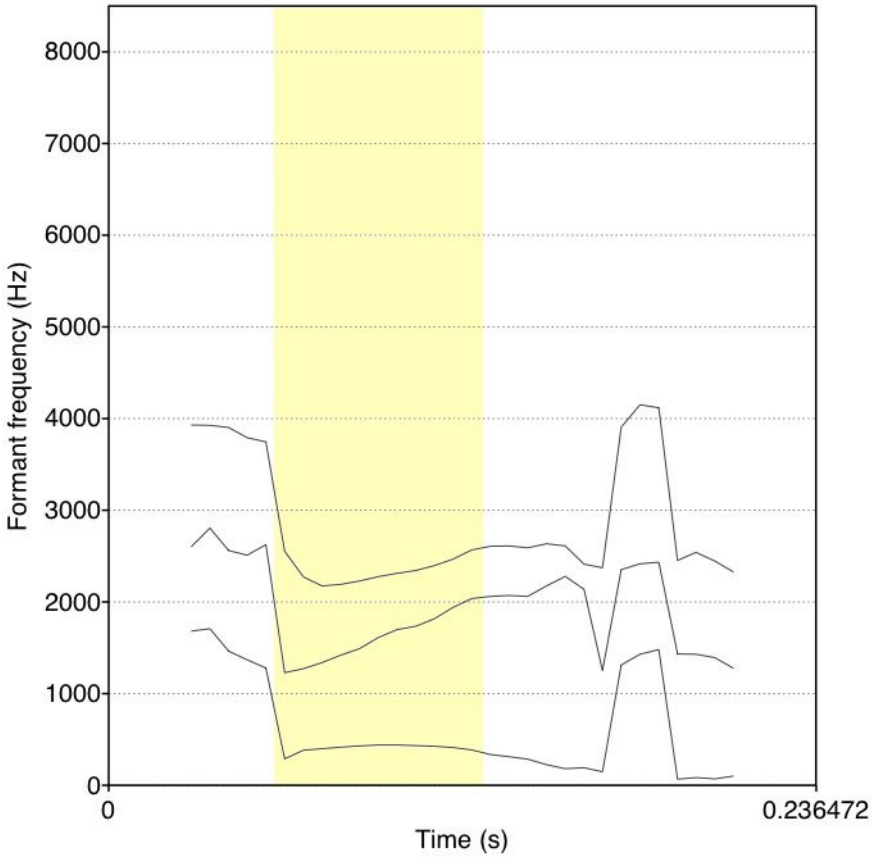

figure 1.): 'bring'

The /ɹ/ phoneme in this utterance is pronounced roughly between 0.06s and 0.10s. This phoneme therefore can be characterised formant-wise by a downward spike at formant graphs F1 to F3 and a subsequent rising slope in all formant graphs with formants F2 and F3 approaching each other.

1 See http://accent.gmu.edu/searchsaa.php?function=detail&speakerid=97

As for the characteristics of the pronunciation of the /æ/ vowel in 'slab', please consider figure 2.):

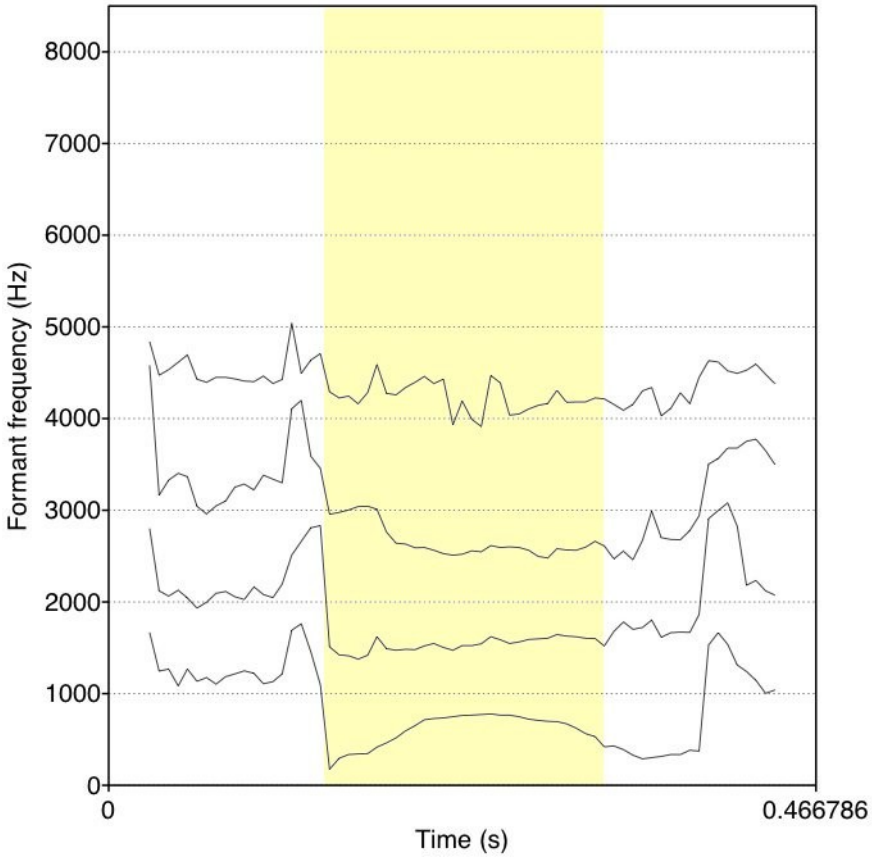

figure 2.): 'slabs'

The vowel is pronounced right between the spikes at 0.19s and 0.31s (the first spike marking the voiced alveolar lateral approximant /l/ and the seconding one denoting the voiced labial stop /b/). First of all, we can see clearly the relatively irregular pattern of F4. Secondly, F2 and F3 more or less display the same distance to their respective lower formant, whereas the distance between F3 and F4 is slightly larger.

Finally, as for our South-Eastern British English sample, we shall have a look at the properties of the /ð/ phoneme by regarding figure 3.), which illustrates the pronunciation of the word 'brother':

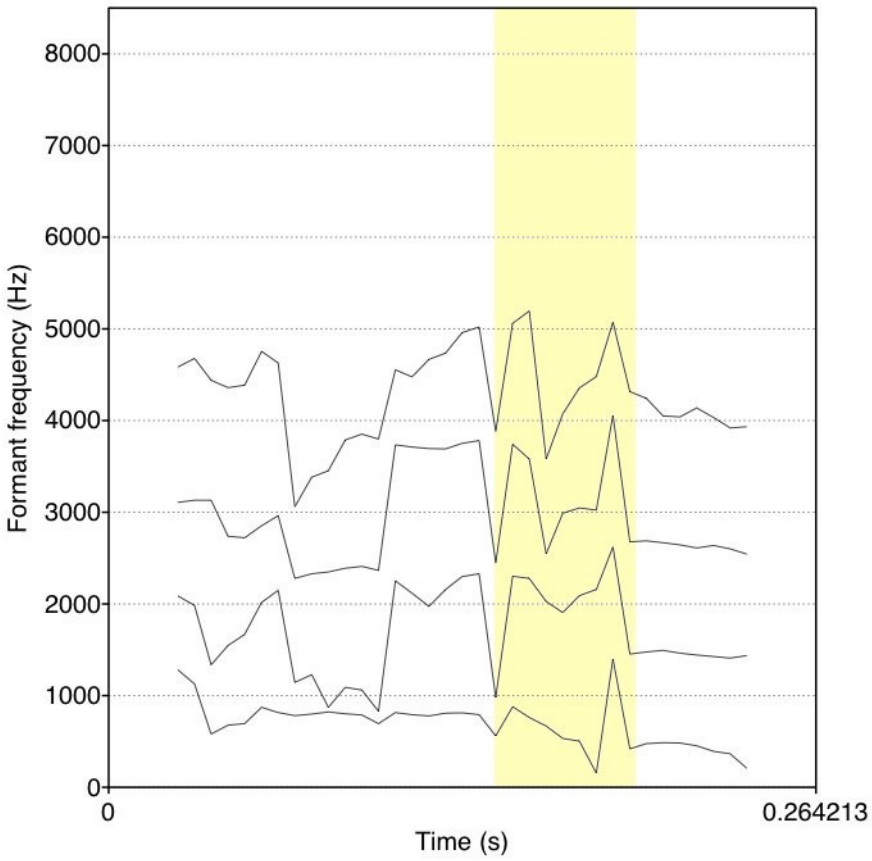

figure 3.): 'brother'

The utterance of the /ð/ phoneme takes place between 0.13s and 0.22s, that is right between the downward spike in formant graphs F2 to F4 and the final upward spike.
Concerning this phoneme the formant graph F1 exhibits a slight downward slope, whereas the other formant graphs display an upward spike followed by an equally sharp downward spike. Before the pronunciation of the mid centre vowel /ə/ in word-final position the formant graphs all show another upward spike. The F2 formant graph is slightly more distant to F1 than the other graphs are towards their respective lower formants. Regarding symmetry one can state that formant graphs F3 and F4 are most similar during pronunciation of the /ð/ phoneme in this sample.

2.2 South-Eastern Irish English accent

After having analysed the formant structure of the phonemes at hand in South-Eastern British English, we now shall do the same for the South-Eastern Irish English accent. This analysis will be carried out by using a sample performed by a speaker from Kilkenny, Ireland[2].

Again, we shall begin with examining the formant structure of the /ɹ/ phoneme as occurring in the word 'bring':

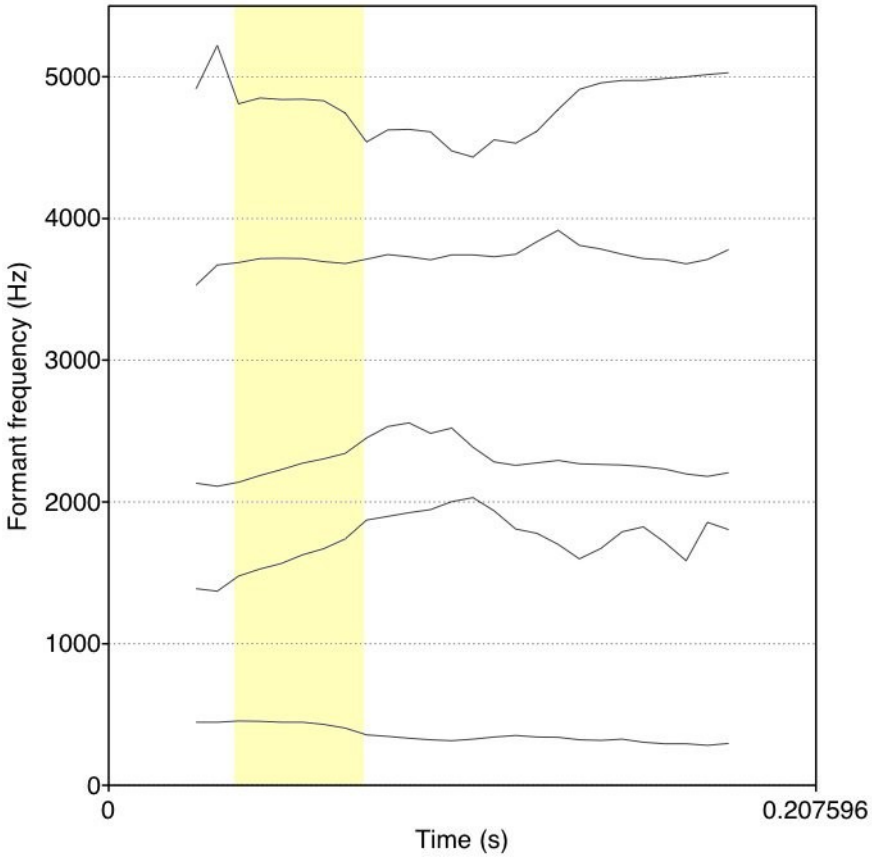

figure 4.): 'bring'

The phoneme is pronounced in this utterance between 0.02s and 0.06s and shows strong similarities to the South-Eastern British English variation analysed before, as we also find a more or less straight line in F1 and rising slopes in both F2 and F3.

2 See http://accent.gmu.edu/searchsaa.php?function=detail&speakerid=135

The formant structure of the /æ/ vowel in 'slab' in South-Eastern Irish English is shown in figure 5.) below:

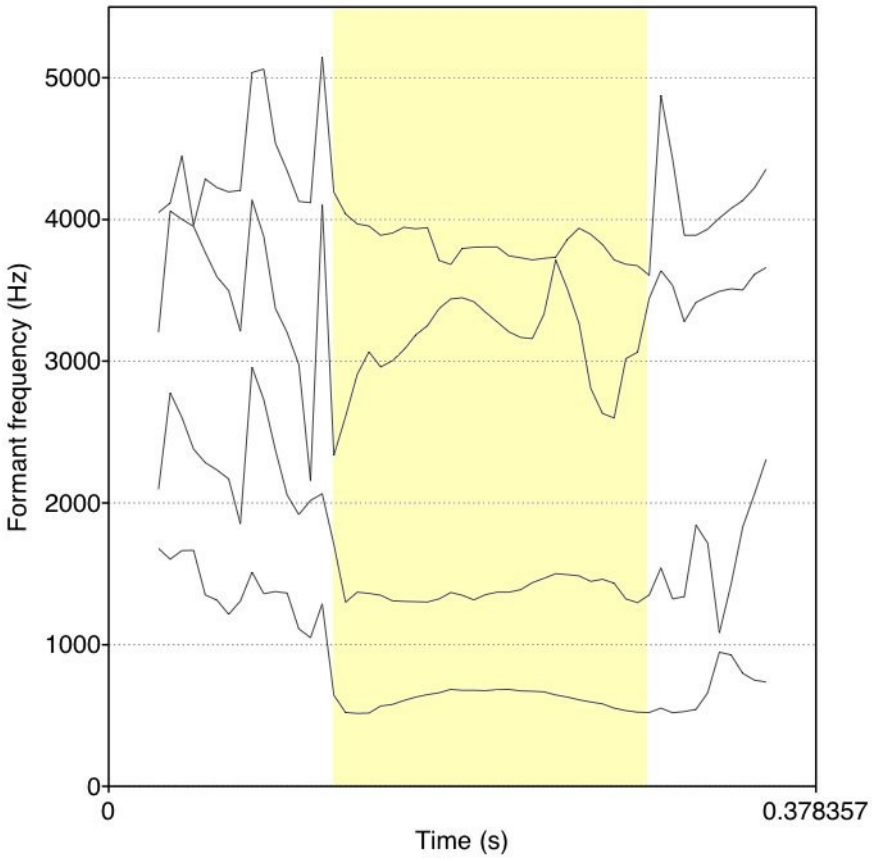

figure 5.): 'slabs'

At first glimpse, the allophone of the /æ/ phoneme uttered here bears some similarities with the one presented in figure 2.) as for formants F1 and F2. However, regarding formants F3 and F4 it becomes obvious that the quality of this vowel is conspicuously distinct from the one occurring in South-Eastern British English.

Coming back to the /δ/ phoneme, we shall have a look at figure 6.), which shows the formant graphs of the word 'brother' as pronounced in the sample at hand:

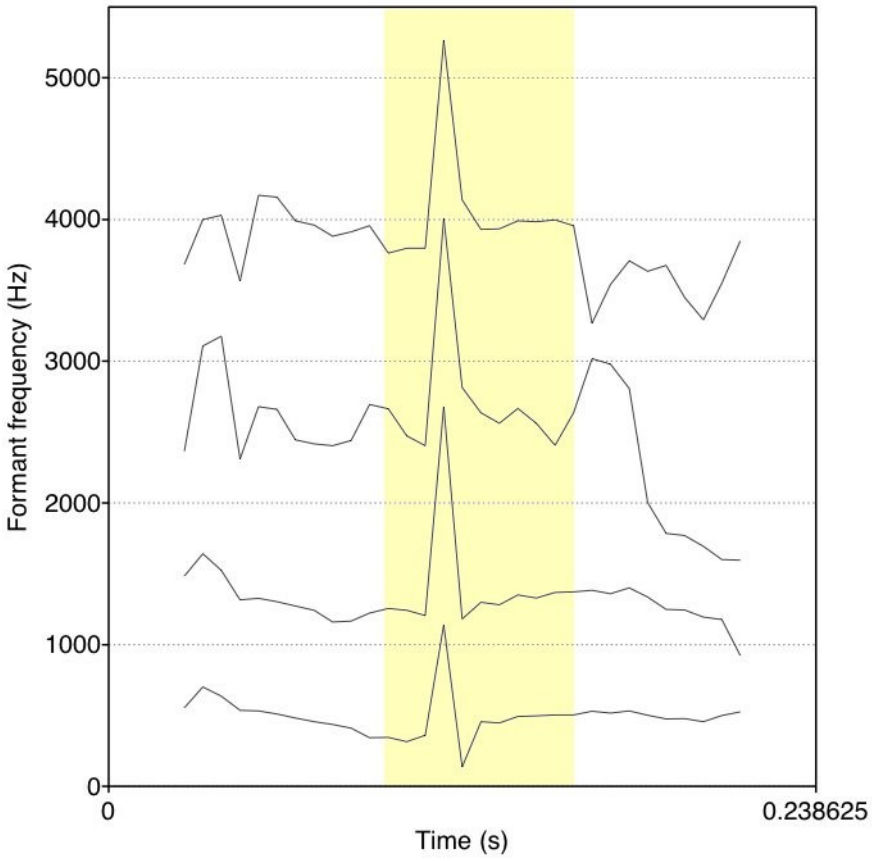

figure 6.): 'brother'

This figure most obviously differs from the formants displayed figure 3.), since it sports no rising spike at the end of the pronunciation of the phoneme in question, which actually is due to the fact that Irish English is a rhotic variant of the English language, whereas British English typically tends to be non-rhotic meaning that word-final 'r's are pronounced like /ɹ/ in Irish English, while they are reduced to the Schwa vowel /ə/ in most British English accents. Thus, the occurrence of the ensuing word-final phoneme has an impact on the word-internal pronunciation of /δ/.

2.3. West Coast American English accent

This final section concerning native English accents will cover the allophonic variations of the /ɹ/, /æ/ and /ð/ phonemes in West Coast American English employing a speech sample by a speaker from Los Angeles, California[3].

To start with, we shall have a look at the formant patterns of the /ɹ/ phoneme exemplified by the pronunciation of the word 'bring' in this particular variant of English:

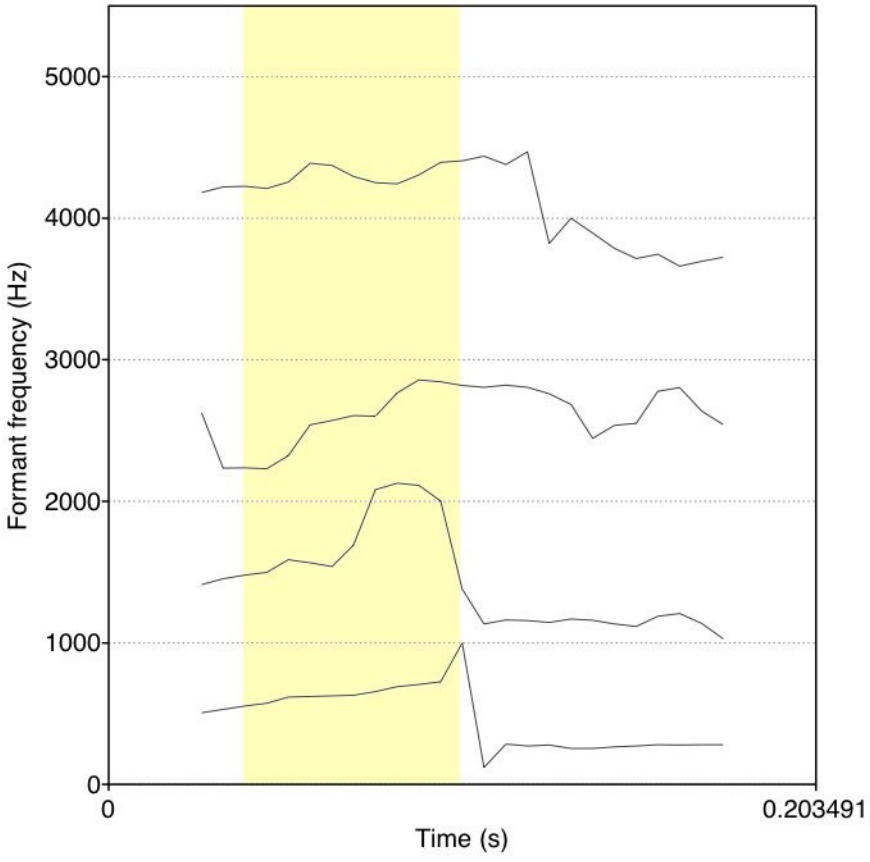

figure 7.): 'bring'

Though structurally similar, the formant patterns clearly contrast with their Irish and British English counterparts as for some of their features, for instance the F2 graph displays a broad spike towards the end of the /ɹ/ sound where the patterns from the other accents only show slightly rising slopes.

3 See http://accent.gmu.edu/searchsaa.php?function=detail&speakerid=408

Figure 8.) shows the formant patterns of the /æ/ vowel taken from the West Coast American English sample:

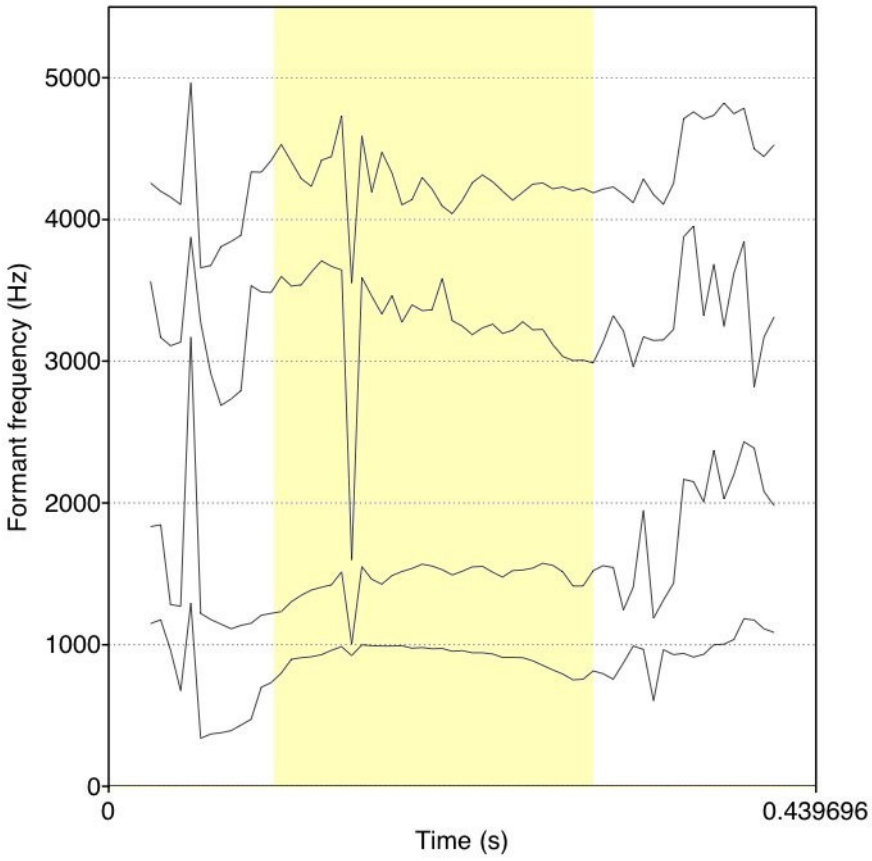

figure 8.): 'slabs'

Again, we can see clearly how different this particular sound is pronounced in this English accent when compared to Irish and British English however similar this sound may seem on a superficial level. For example the formant graphs for formants F2 to F4 all sport a steep spike at 0.15s, whereas the graphs in the other slabs remain in a much more narrow range during pronuniation of this sound.

We shall now have a final look at the features of the pronunciation of the word-internal /ð/ sound in West Coast American English by considering figure 9.):

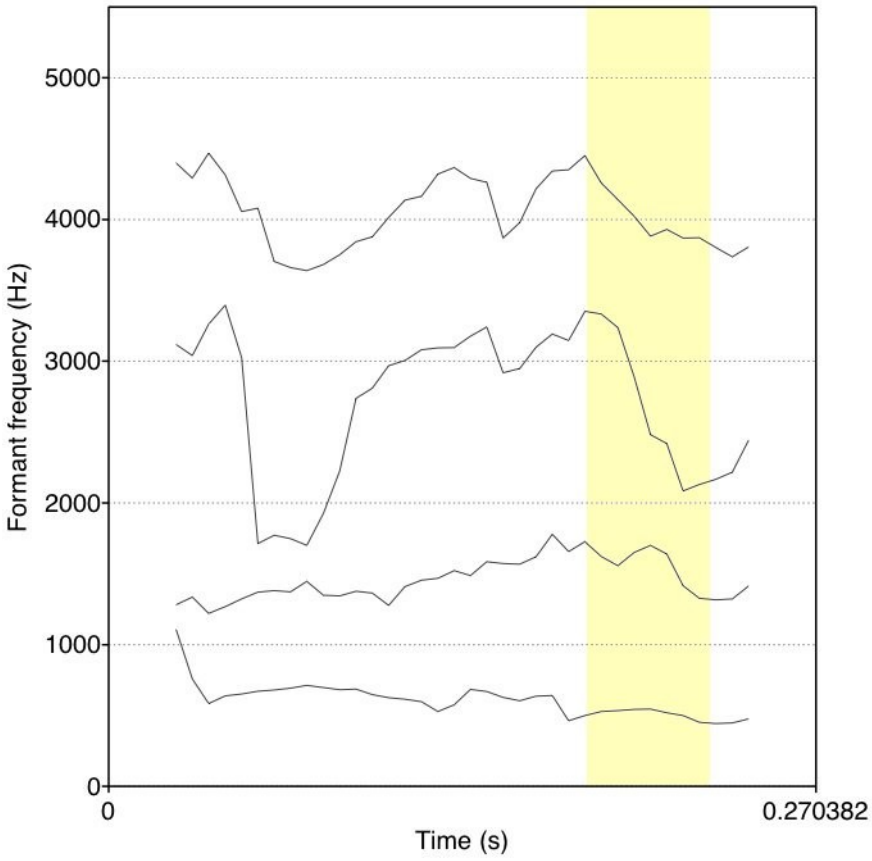

figure 9.): 'brother'

When comparing these formant graphs to the ones in figures 3.) and 6.) it becomes obvious that the patterns are completely different in each of the samples, which, as already has been mentioned in section 2.2, is caused by the fact that the surrounding sounds are pronounced completely differently in each of the accents presented here, which in turn has an impact on neighbouring sounds as well.

3. Phonetic analysis of non-native English accents

3.1 German English accent

After having explored the formant patterns of the /ɹ/, /æ/ and /ð/ phonemes in several native variants of the English language, we shall now turn to non-native English accents, starting with the accent often exposed by German speakers of English. The speech sample provided for this purpose was uttered by a native German speaker from Dusseldorf, Germany[4]

4 See http://accent.gmu.edu/browse_language.php?function=detail&speakerid=189

The graphs in figure 10.) display the formant patterns of the word 'bring' as pronounced by this particular speaker:

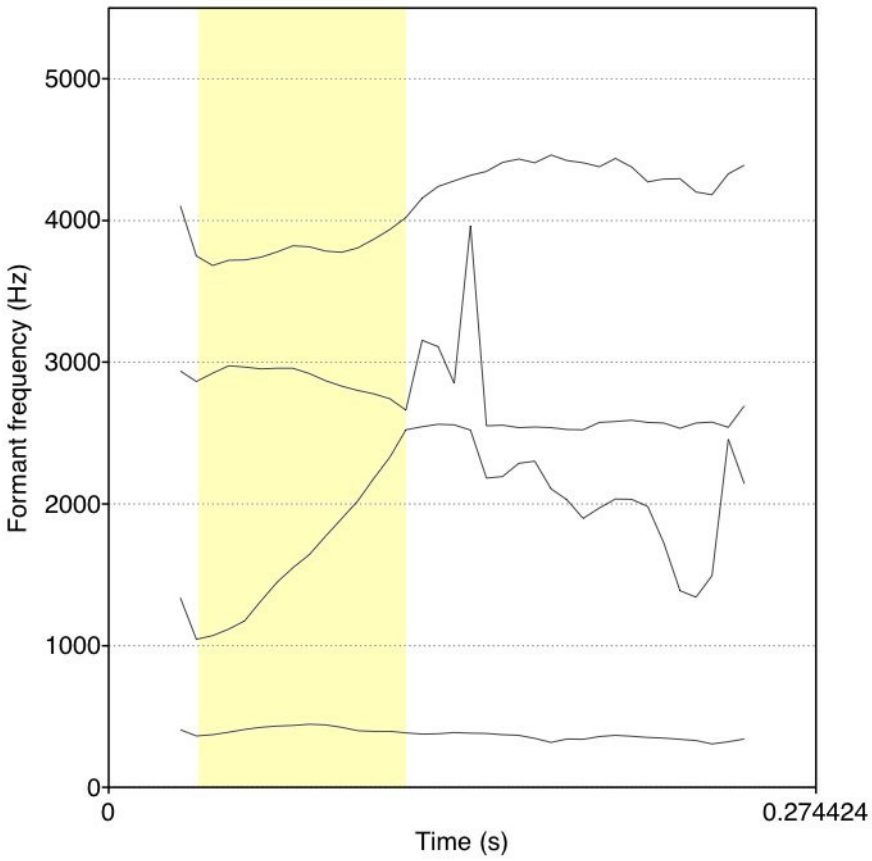

figure 10.): 'bring'

The patterns during pronunciation of the /ɹ/ phoneme shown here differ from all the native samples in that there is a steep rise in the F2 graph. This property can be accounted for by the fact that the sound associated with the 'r' grapheme in German is pronounced as a voiced uvular approximant (/ʁ/), whereas in English we have the aforementioned voiced alveolar approximant /ɹ/ (with different degrees of retroflexivity).

The formant patterns exposed during pronunciation of the /æ/ vowel in the German accent sample can be seen in figure 11.):

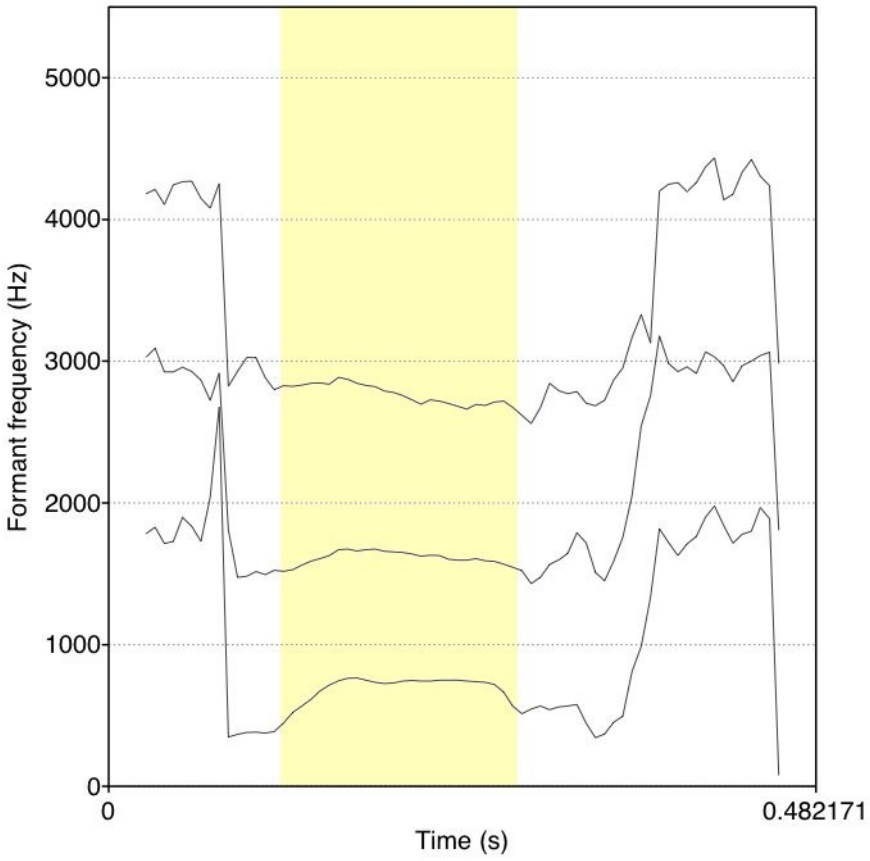

figure 11.): 'slabs'

In this excerpt we can see three relatively steady graphs for the /æ/ sound with only slightly rising slopes in the beginning and a falling slope at the end, while the native speaker samples, at least to some extent, all sport 'feature-rich' formant graphs with several spikes and slopes. This behaviour can be explained by the phoneme being pronounced by the German speaker with a tongue position slightly higher than usually is the case for native English speakers. Thus, the sound becomes something that is more like /ɛ/ than /æ/.

Finally, as for the German accent example, we shall deal with the sound associated with the grapheme 'th' as pronounced by the German speaker. Figure 12.) shows the formant patterns for the pronunciation of 'brother' by this speaker:

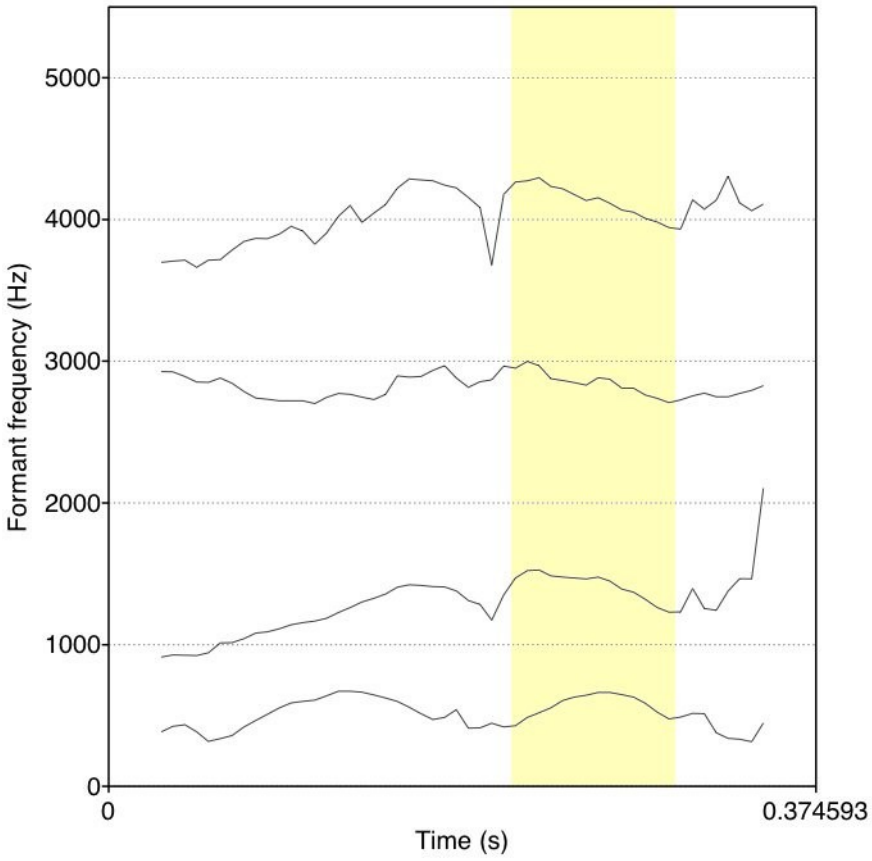

figure 12.): 'brother'

Not surprisingly, the formants during pronunciation of this sound differ from the native samples, too. Again, this sample shows more or less steady graphs with only slightly falling slopes, which appears to be due to the fact, that the sound associated with word-internal 'th' tends to be pronounced more like the voiced alveolar stop /d/ by speakers with a broad German accent.

3.2 Spanish English accent

For our examination of non-native English accents, we now shall have a brief look at the pronunciation of the /ɹ/, /æ/ and /δ/ phonemes in another non-native English sample, in this case uttered by a native Castilian speaker from Madrid, Spain[5].
First of all, figure 13.) presents us with the formant features of the pronunciation of the word 'bring' from this sample:

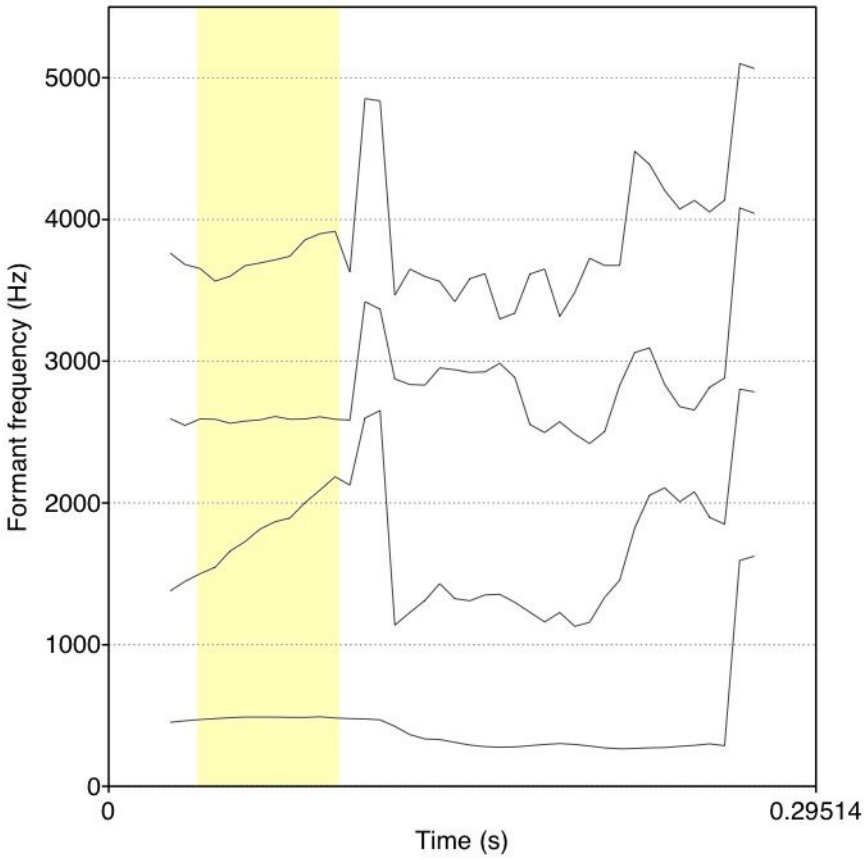

figure 13.): 'bring'

This excerpt shows a rising slope in F2 and F4 and more or less level graphs for F1 and F3, which distinguishes the pattern from the native samples, which consistently expose rising slopes at least for the F2 and F3 graphs during pronunciation of the /ɹ/ sound.

5 See http://accent.gmu.edu/searchsaa.php?function=detail&speakerid=337

The formant eatures of the /æ/ vowel in the Spanish English sample can be derived from figure 14.):

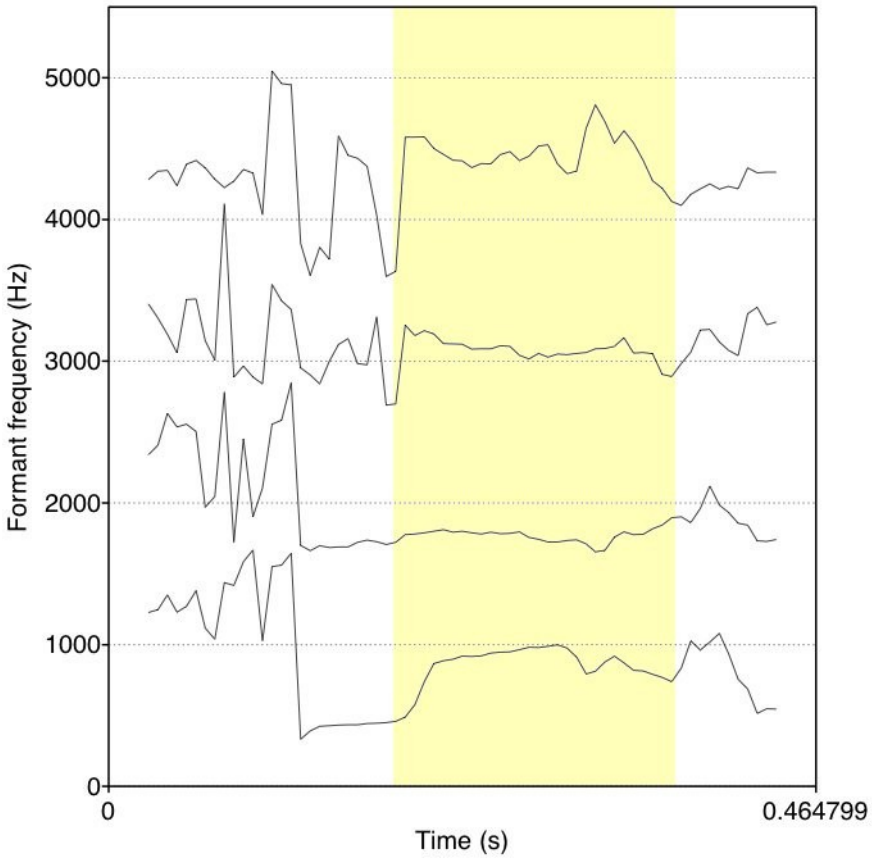

figure 14.): 'slabs'

The graphs from this excerpt bear a striking similarity with the German sample and indeed it can be said that the vowel in this example is realised as /ɛ/ instead of /æ/, as is the case for German speaker.

Last not least, figure 15.) displays the formant patterns of the word 'brother' as pronounced by the Madrid speaker:

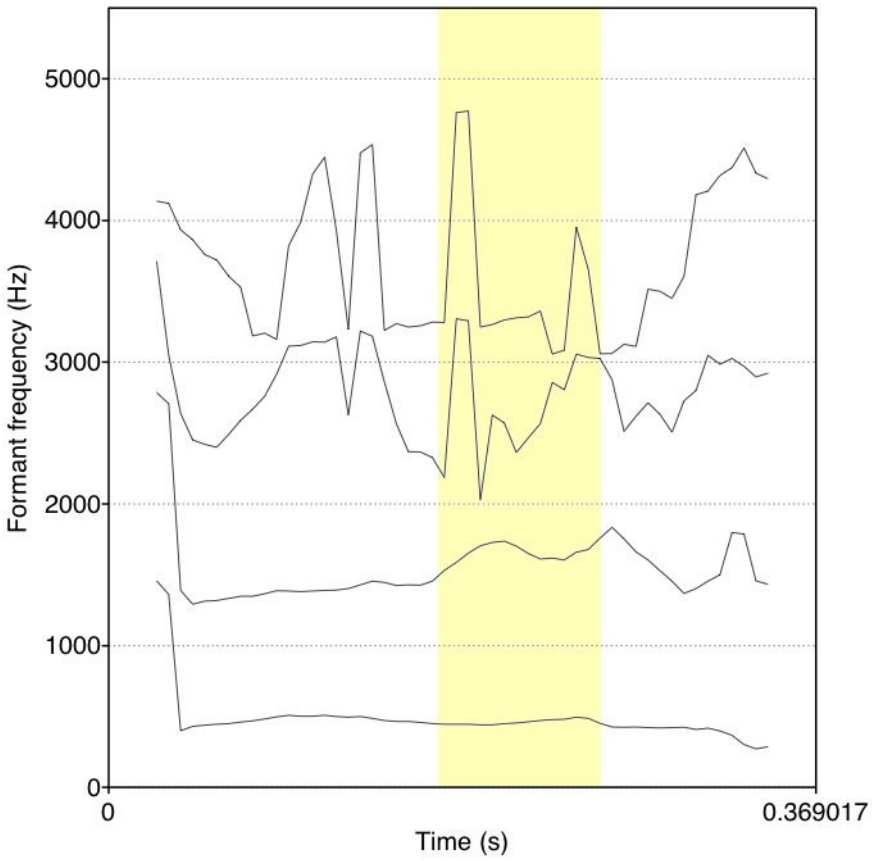

figure 15.): 'brother'

These formant graphs bear no similarity whatsoever with any of the ones shown before in the figures for the utterances of 'brother' in the other accents and indeed the sound is very different from all the other samples being something like a tapped variant of the fricative represented by /δ/.

4. Summary and Conclusion

In this article we tried to elucidate in how far it is possible to make use of non-native language data in order to gain knowledge about the properties of a speaker's native language competence.

For this purpose we took English speech samples uttered by several speakers, both native, South-Eastern British, South-Eastern Irish and West Coast American in this case, and non-native, German and Spanish respectively, and compared them regarding their respective features.

Our goal was to show that an approach leveraging language data from one language which has been uttered by speakers with native languages other than the one the data pertains to, might come in particularly handy when comparing language or accent features.

It has been shown that speakers tend to transfer the 'speaking habits' they have learned during native language acquisition to non-native second languages, which is why speakers can recognise a foreign accent and infer possible properties of a language without even having heard a genuine sample from that particular language.

In this work we attempted to outline some of these differences for a set of native and non-native accents by analysing excerpts from speech samples according to the formant patterns exposed by the speakers when uttering the lower front vowel /æ/ (as in 'slab'), the word-internal voiced dental fricative /ð/ (as in 'brother') and the voiced alveolar approximant /ɹ/ (as in 'bring') from the English phoneme inventory.

We have shown that distinctive traits of languages (and language accents for that matter) can be recognised clearly by the formant patterns they expose.

Apart from the purpose of this method which has been mentioned above, that is deducing and comparing properties of languages without having native language samples at one's disposal, one could also think of applications in spoken language processing. For instance, it is possible to train a speech recognition software based on Hidden Markov Models according to the accents which are exposed by the speakers using the software. That is to say, such a software could be trained accent-wise after having recognised the speakers accent which in turn would lead to much better recognition results (Arslan/Hansen, 1996: 367).

Another example of the usage of phoneme features such as formant patterns is a spoken language identification approach by Berkling/Barnard (1994) which involves clustering algorithms for a broad phoneme classification. Depending on how strict such a classification is devised, it could be possible to either distinguish between language accents or to still deal with them as belonging all to the same language.

Finally, it is conceivable that the approach taken in this work, does not only apply to phonetics, but can be extended to other areas of linguistics as well, since non-native

speakers of a language typically not only show the propensity to transfer phonetic traits from their native language, but syntactic and semantic (and possibly morphological and pragmatic) ones, too.

5. References

- Arslan, Levent M./Hansen, John H.L. (1996): *Language Accent Classification in American English*. In: *Speech Communication, volume 18, issue 4*; 353-367. Amsterdam, The Netherlands: Elsevier.
- Berkling, Kay M./Barnard, Etienne (1994): *Language identification of six languages based on a common set of broad phonemes*. In: *Proceedings of International Conference on Spoken Language Processing volume 4*; 1891-1894 Yokohama, Japan.
- Boersma, Paul/Weenink, David, Institute of Phonetic Sciences, University of Amsterdam, Amsterdam, The Netherlands: *Praat: doing phonetics by computer*, Version 4.4.25 of July 16, 2006: http://www.praat.org/.
- Weinberger Stephen H. et al., Department of English, George Mason University, Fairfax, Virginia, USA: *Speech Accent Archive*: http://accent.gmu.edu/.

6. Appendix: Elicitation Paragraph

'Please call Stella. Ask her to bring these things with her from the store:
Six spoons of fresh snow peas, five thick slabs of blue cheese, and
maybe a snack for her brother Bob. We also need a small plastic snake
and a big toy frog for the kids. She can scoop these things into three red
bags, and we will go meet her Wednesday at the train station.'
(quoted from: http://accent.gmu.edu/pdfs/elicitation.pdf , the underlined words are the ones which were used for extracting the sounds which have been examined in this work)