Second language research:

Mastering the temporal pattern of English

An acoustic-phonetic study about plasticity in vowel durations of Dutch speakers of English

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This study examines the development of the temporal pattern of proficient Dutch speakers of L2 English who live in an international environment and who speak English as a lingua franca. Question is how these students change their temporal pattern within a year when they have extended L2 experience during that year. This study focuses specifically on how the pattern of vowel durations changes in respect to the fortis-lenis (i.e. voiceless-voiced) distinction. In English, vowel before fortis consonants are shortened, while they have full length in other contexts. Dutch also has this distinction, but this contrast is neutralized in word-final position. Question is thus how Dutch speakers of English behave on a familiar contrast in an unfamiliar position. During their first year on campus the Dutch speakers were recorded two times: at the beginning and end of their first year. Additionally, native English speakers were recorded to form the control group. Vowel durations of these groups were analyzed on the basis of three variables: final consonant (fortis/lenis), vowel identity and the position of the target word in the sentence. Results indicate that after a year in an English-speaking environment, Dutch speakers of English have changed their temporal pattern. They have overall shorter durations than at the beginning of the year, indicating that they became more fluent and proficient. This idea is supported by an observed increase in overall speech rate. But although speakers become more fluent, their temporal pattern still differs from that of the native speakers both in respect to the fortis-lenis contrast as in respect to the amount of final lengthening on items in sentence-final position. The temporal pattern of English is thus, even for highly proficient L2 speakers, extremely difficult to master.

1. BACKGROUND

1.1 INTRODUCTION

The temporal pattern of speech – i.e. the pattern of segment durations – carries linguistic meaning like rhythm, stress, intrinsic vowel identity, and the location of boundaries (Klatt 1976). Although Dutch and English have similar rhythms, the temporal patterns of these languages differ. In English, vowels duration is dependent on the following (word-final) consonant. Vowels are shortened before fortis (i.e. voiceless) consonants but have full length before lenis (i.e. voiced) consonants (Bent, Bradlow, and Smith 2008; Elsendoorn 1985; Klatt 1976; Tsukada 2009; van der Feest and Swingley 2011). In Dutch however, the effect of the following consonant on vowel length is neutralized in word-final position. Elsendoorn (1985) found that Dutch speakers of English produce deviant vowel durations on this contrast relative to native speakers, but this has only been shown for high school students. Therefore, the present study investigates how Dutch speakers of English change their temporal pattern – especially focusing on vowel durations before word-final fortis and lenis consonants – when they gain more second language (L2) experience.

There is ample evidence that interlocutors speaking the same language tend to move toward each other – i.e. converge - during communication (Giles, Coupland, and Coupland 1991). This has been shown for several features such as utterance length, speech rate, pausing frequencies, gestures, head nodding, facial affect and posture (Giles, Coupland, and Coupland 1991). This has also been shown for vowel formant frequencies of speakers who have a different accent or regiolect, but share the same first language (L1) (Babel 2010; Delvaux and Soquet 2007; Evans and Iverson 2007). The present study addresses the question if Dutch speakers of English also show converging temporal patterns when they interact with other L2 speakers of English.

The present study investigates these two questions – namely (1) how does an increase in L2 experience influences the temporal pattern of Dutch speakers of English, focusing on the fortis-lenis

contrast, and (2) do Dutch speakers of English show converging temporal patterns when they have interaction with other L2 English speakers. This study looks at Dutch university students who live closely together in an international setting and speak English as a lingua franca. The aim of this study is thus to investigate how the temporal pattern of Dutch speakers of L2 English develops over time.

In the remaining sections of this chapter, relevant literature will be discussed in the light of the research question. Chapter 2 describes the methodology and Chapter 3 discusses the results of the experiment. This paper ends with a discussion and conclusion (Chapter 4).

1.2 SUPRASEGMENTALS

1.2.1 RHYTHM

Features of spoken language which are not easily identified as discrete segments are variously referred to as *prosodic* features or *suprasegmental* features (Clark, Fletcher, and Yallop 2007). In this paper, these terms will be used interchangeably. Suprasegmental properties of speech, such as melody and rhythm, cannot, unlike other speech properties, be derived from the underlying sequence of phonemes. Typically, melody is defined as "the ensemble of *pitch variations* in the course of an utterance" (Hart, Collier, and Cohen 1990) and speech rhythm as "the ensemble of speech *sound durations*, that together constitute the *temporal pattern* of speech" (Nooteboom 1997). This paper will focus on the latter.

Different languages exhibit different speech rhythms (Abercrombie 1967; Pike 1945). Both Dutch and English are said to be stressed-timed, meaning that sentence stress is the basis of rhythm of these languages. In stress-timed languages, stressed syllables tend to occur at roughly equal intervals of time. This is achieved mainly by lengthening stressed vowels and compressing unstressed vowels (Collins and Mees 2003a). Other languages work on a syllable-timed principle, and maintain a roughly equal length for each syllable, like French and Italian (Pike 1945; Collins and Mees 2003a). The distinction between stressed-timed and syllable-timed is, however, controversial and not as clear-cut

as presented, see White and Mattys (2007) for a longer discussion. For the purposes of this paper it suffices to note that English and Dutch have similar rhythmical patterns.

In L2 research, it has been suggested that the rhythm of a speaker's L1 is, at least partially, transferred to the speaker's L2. This has indeed been found for Thai speakers of English (Sarmah, Gogoi, and Wiltshire 2009) and Japanese speakers of English (Oh et al. 2011). Furthermore, it has been found that prosody – and thus also rhythm - is an important factor in the intelligibility and accentedness of foreign accented (i.e. non-native) speech (Boula de Mareuil and Vieru-Dimulescu 2006; Kang 2010). But, not all suprasegmental speech properties contribute equally to this perceived accent and not all suprasegmental properties are acquired with the same speed (Trofimovich and Baker 2006; Trofimovich and Baker 2007). Overall, this suggests that some prosodic properties of L1 speech may be transferred into a speaker's L2. Additionally, certain L2 suprasegmental properties can be learned over time, while others might be in fact never learned to native-like accuracy.

1.2.2 Temporal Pattern

The temporal pattern of speech is closely related to rhythm. But, rhythm and temporal pattern are not the same. While the *variation* or *alternation* of different segment durations – especially vowel durations - is the basis of speech rhythm, the basis of the temporal pattern of speech is the *ensemble* of all segment durations together. In this sense, speech rhythm is a function of the temporal pattern of speech.

With the temporal pattern, more factors come into play. This paper will focus on *vowel length* as operationalisation of segment duration. Vowel length is not only influenced by stress, as in the case of rhythm, but also depends on a number of other factors. First, each vowel has its own intrinsic length; for example, the vowel /i/ as in *feed* is longer than the vowel /u/ in *food* (Clark, Fletcher, and Yallop 2007; Van Santen 1992). Second, the number of syllables in a word affects vowel length. The more syllables, the shorter the length of a vowel. This process is called *compensatory shortening* (Nooteboom 1997; Klatt 1976). Third, the specific position within a word and sentence influences

vowel length (Klatt 1976). Vowels in the last syllable of a word are considerable longer than the other vowels (Nooteboom 1997; Klatt 1976) and vowels in segments immediately preceding sentence boundaries and major and minor phrase boundaries are considerably longer than vowels in other syllables. (Nooteboom 1997; Klatt 1976; Van Santen 1992). This process is called *final lengthening* (Nooteboom 1997) and may contribute to the detection of word boundaries (Quené 1992; Shatzman and McQueen 2006ab). Fourth, vowel durations are also associated with the absence or presence of emphasis (Klatt 1976) with longer vowel durations for emphasized syllables. Fifth, speech tempo also affects vowel duration, with shorter vowel duration for higher speech rate. Stressed syllables are affected less by an increase in speech rate than unstressed syllables (Lehiste 1970). But, the higher the speech tempo, the less shortening we find (Nooteboom 1997). There are thus many different factors acting simultaneously on the temporal patterns of speech. This makes it hard to give a systematic account for durational patterns. There may be (extreme) interactions between factors. This has indeed been found; see (Klatt 1976; Van Santen 1992). Furthermore, the organization of vowel durations differs cross-linguistically. There are substantial differences in the extent to which temporal patterns are realized between languages (Bent, Bradlow, and Smith 2008; Collins and Mees 2003a), even between languages with similar rhythms as in the case of English and Dutch. This study focuses on the temporal differences between these languages.

Both English and Dutch have *fortis* and *lenis* consonants. The fortis-lenis distinction is related to energy of articulation with fortis consonants produced with stronger and voiceless articulation, and lenis consonants produced with weaker and (potentially) voiced articulation (Clark, Fletcher, and Yallop 2007; Collins and Mees 2003a). Only stops and fricatives are affected by this contrast. At phonemic level, the systems of the two languages are similar. One crucial difference, however, is that, unlike English, Dutch has no fortis-lenis contrast in word-final position, due to a phonological process (i.e. *final devoicing*) that devoices all voiced consonants in final position. This means that in Dutch, the words *hout* and *houd* ('wood' and 'keep') are produced identically in respect to vowel

length and other phonetic properties. For English however, the words *nip* and *nib* are produced differently, because in English (except Scottish), vowels are shortened before word-final fortis consonants but have full length in other contexts (i.e. word-finally, before lenis consonants, and before nasals and /l/) (Collins and Mees 2003b; Hogan and Rozsypal 1980; House 1961). Vowel duration is not the only perceptual cue in distinguishing fortis from lenis consonants in word-final position. Other factors - such as spectral information like voice bar duration, silent closure duration and burst/fricative duration – also contribute to the perception of this contrast (Hogan and Rozsypal 1980; Slis and Cohen 1969ab). For English, however, vowel duration is the primary perceptual cue for distinguishing word-final fortis and lenis consonants.

Like fortis and lenis consonants, both English and Dutch have *tense* and *lax* vowels. In both English and Dutch, lax vowels are generally shorter than tense vowels and they cannot occur in word-final stressed open syllables. Tense vowels are typically longer in duration and may occur in any context, including word-finally (Collins and Mees 2003b). Although both English and Dutch have tense and lax vowels, they may use different means of realizing this contrast. The absolute durational realizations of spectrally similar vowels may differ (Bent, Bradlow, and Smith 2008), which poses the L2 learner with a potential problem.

In summary, the duration of vowels depends on a variety of factors like stress, intrinsic vowel identity, speech tempo and the position of the vowel within a word or sentence. Some aspects of vowel duration are language specific. For English, the duration of the preceding vowel is important in the identification of word-final fortis and lenis consonants. Dutch lacks this contrast in word-final position. The absence of this contrast in Dutch presents the Dutch learner of English with a potential problem in both production and perception.

1.3 L2 TEMPORAL PATTERN: PRODUCTION AND PERCEPTION

For second language learners, the temporal pattern of the second language may lead to incorrectly produced and perceived durations in that L2, since speakers will be influenced by their mother tongue (Bent, Bradlow, and Smith 2008; Elsendoorn 1985). A non-native or modified temporal pattern may lead to a perceived foreign accent (Flege 1993) and a decrease in intelligibility of L2 and deaf speech (Maassen and Povel 1984; Quené and van Delft 2010; and Tajima, Port, and Dalby 1997). This section discusses studies about production and perception of L2 temporal patterns, again specifically focusing on vowel durations.

For production, Elsendoorn (1985) found that Dutch speakers of English behave differently on the word-final fortis-lenis distinction; the Dutch speakers of English differed from the native speakers both on the pattern and the amount of shortening found. Speaker proficiency did not significantly affect the results, but it must be noted that Elsendoorn (1985) used Dutch speakers of English speakers who had only high school experience with the English language. (Oh et al. 2011) found that, for Japanese speakers of English, the age of acquisition is an important factor in native-like L2 vowel production; the younger the acquisition, the better the results. But this does not answer the question to what extent more experience with English, for adult learners, influences the production of the L2 temporal pattern; this will be addressed in the present study. Speakers of other languages than Dutch also find it difficult to produce native-like durations on the fortis-lenis contrast. This has been found for Mandarin speakers of English (Flege 1993; Bent, Bradlow, and Smith 2008) , Thai speakers of English and Japanes speakers of English (Tsukada 2009). The tense-lax distinction, however, appears to be much easier for Dutch speakers of English (Elsendoorn 1985) and Mandarin speakers of English (Flege 1993; Bent, Bradlow, and Smith 2008), even if the contrast does not exist in the L1 of the speaker as in the case of Mandarin speakers. In terms of perception, L2 speakers also behave differently than native speakers on these contrasts. In perception experiments, it has been consistently showed that, despite the use of vowel duration in their L1, Dutch speakers of English,

even with ample experience, do not use vowel duration in the same way as native speakers of English do (Broersma 2005; Broersma 2008; Broersma 2010; van der Feest and Swingley 2011; Bent, Bradlow, and Smith 2008).

Thus, native-like vowel durations on the word-final fortis-lenis contrast are difficult to master for L2 learners of English. Even with extended training and experience, L2 learners are unable to reach native-like accuracy on this contrast in both production and perception. Although L2 learners of English never reached native-like accuracy on the fortis-lenis contrast, there are indications that experience with the language improves the performance on this contrast. Flege (1993) showed that experienced late L2 learners showed better scores than inexperienced L2 learners, although they still did not reach native-like accuracy.

1.4 CONVERGENCE

It has been consistently shown that interlocutors of the same language tend to converge toward each other during communication. This has been shown for several features such as utterance length, speech rate, pausing frequency, gestures, head nodding and facial affect and posture (Giles, Coupland, and Coupland 1991). This has also been shown for speakers who have a different accent or regiolect, but share the same L1 (Babel 2010; Delvaux and Soquet 2007; Evans and Iverson 2007). These authors studied accent convergence both acoustically (in terms of formant values) and socio-phonetically and found that speakers robustly converge, both perceptually and acoustically, when they hear, or speak with, speakers with a different, but native-accent. This convergence effect occurs always, it is automatical and unintentional. The magnitude of the effect is modulated by several (socio) linguistic factors such as the sex, the age, and the role of the speaker, the relative frequency of the imitated word and the attitude towards the imitated speaker. Furthermore, the effect of convergence remained present until several minutes after exposure to the accented speaker (Delvaux and Soquet 2007). Little research has addressed the question what happens when speakers with different L1s come together and use L2 English as a lingua franca. Question is also which other

speech properties are actually affected by convergence in this situation of. One of the questions addressed in the present study is if Dutch speakers of L2 English converge their temporal patterns, when they are exposed to, or talk with other L2 speakers originating from a variety of language backgrounds.

1.5 The Present Study

The present study investigates the questions discussed in previous sections – namely (1) how does L2 experience influence the temporal pattern of Dutch speakers of English, focusing on the fortis-lenis contrast, and (2) do Dutch speakers of English show converging temporal patterns when they have interaction with other L2 English speakers. Combining these questions leads to the main research question of how the temporal pattern of Dutch speakers of L2 English develops over time when speakers grain more L2 experience. This research question may be assessed by recording Dutch speakers of English repeatedly, e.g. two times in their first year on campus: at the beginning and end of their first year. Additionally, recordings of a control group of native English speakers form the baseline for comparison. Patterns of vowel durations are the primary measure to assess the temporal pattern of Dutch speakers of English. Vowel durations per group and session are compared on the basis of the factors: vowel identity, final consonant (fortis or lenis) and position (non-final, phrase-final and sentence-final). Speech rate is also taken into account.

The present study is part of a longitudinal study (For a project description see Orr et al., *in press*) about accent development. In this larger research project, the question is how speakers' accents change over time in an international spoken English environment. This international spoken language environment is University College Utrecht, hence UCU, in which English is spoken as a lingua franca by speakers of different L1 backgrounds. The core hypothesis of this research project is 'that the native or non-native accent of UCU students will gradually converge to a single common international variety of English, which we call *UCU English accent'* (Orr et al., *in press*).

Because Dutch will be a strong influence, the prediction is that the characteristics of Dutch (vowel) durational patterns remain, at least partially, present in the data. Overall, Dutch speakers of English will probably have shorter durations for spectrally comparable vowels (Elsendoorn 1985), but this effect might be masked by the slower speech rate. A slower speech rate is often found for L2 speech (De Jong et al. *in press*; Trovimovich and Baker 2007). Furthermore, the prediction is - as previously discussed in section 1.3 - that Dutch speakers of English, although aware of the contrast, have difficulties varying their vowel durations natively in respect to the fortis-lenis contrast. This pattern will presumably be visible even after a year of extensive L2 English experience. The expectation is also that the Dutch speakers of English become more fluent within a year; resulting in overall higher speech rates and thus also overall shorter vowel durations (De Jong et al. *in press;* Yuan, Liberman, and Cieri 2006). For all groups, the prediction is that vowel durations of words in non-final position will be shorter than vowel durations of words in phrase-final or sentence-final position. However, Dutch speakers of English may find it difficult to lengthen phrase-final and sentence-final vowels natively, due to the increased cognitive load imposed by speaking in a second language. Furthermore, the prediction is that all factors – i.e. vowel identity, final consonant, position and speech rate – and their interactions, will be important in the explanation of the observed variance. Lastly, if speakers show converging temporal patterns, then the variance between speakers should decrease over sessions.

2. METHODOLOGY

2.1 PARTICIPANTS

The population investigated in this study is a group of young adults who study and live closely together at University College Utrecht (UCU), the Netherlands. During their 3-year curriculum students spend almost all their time on campus; they only have relatively sparse contact with the world outside UCU. All education is in English and students are strongly encouraged to use only English outside class. The majority of the students are native speakers of Dutch (approximately 60%). Only 4% of the students are considered native speakers of English. This latter subset is not homogeneous; these native English speakers speak different varieties of English – e.g. British, American, Canadian and South African English. The remaining part of the population originates from a wide variety of other languages. The international character of UCU and the relative isolation of the student population make UCU the perfect environment to study L2 accent change. The students are divided into two groups, namely (1) monolingual Dutch speakers of English and (2) a control group of native English speakers, not part of the UCU student population. Even at the beginning of their studies, all participants are considered highly proficient speakers of English, because non-native speakers are required to demonstrate proof of proficiency in order to be eligible for admission, since English is the official language at UCU.

For the first recording session (session I), 42 monolingual Dutch speakers were recorded (mean age: 18.0 years; range: 17-20 years; males: 37%; average number of years living in English speaking country: 0.0; range: 0-1 years). Due to technical failure, the recordings of one participant were lost, resulting in a total of 41 monolingual Dutch speakers of English for the first recording session. For the second recording session (session II) at the end of the first year of study, all 42 monolingual Dutch speakers were asked to participate again. Of these 42 students, 33 actually participated in the second recording session. The control group consisted of 10 native monolingual speakers of English (mean age: 21.5 years; range 20-27years; males: 25%; average number of years living in English

speaking country: 20.1; range: 18-22 years). None of the students reported any hearing or speech difficulties.

2.2 MATERIALS

Materials consisted of 57 target words, originating from 3 texts and 5 isolated sentences, see Appendix I and II. The target words were chosen from the texts and sentences in such way that they captured the tense-lax distinction together with the word-final fortis-lenis contrast. Because this study is part of a larger project, the materials words were already chosen. Additionally, the position of the target word was taken into account. Only monosyllabic words with a (C)CVC structure were allowed. Semantically rich target words were chosen, because vowels in unstressed function words are likely to be strongly reduced and thus more difficult to measure. The consequence is that the design is not as balanced as could be and not all contrasts are captured equally well, but all contrasts essential for this study (i.e. fortis-lenis, tense-lax) were present. The following vowels were used: /ɑ, æ, ʌ, ɔ, aɪ, ɛ, eɪ, ɪ, i, ʊ, u/. The word-final sounds/p t k f θ ʃ/ were regarded as fortis consonants and the sounds /b d g v z (m n ŋ l r)/ as lenis consonants. Sounds between brackets () are officially not considered lenis consonants, but, for practical reasons, they were put together here with the lenis consonants. Because vowels may be regarded as shortened before fortis consonants and having full length in other contexts (Collins and Mees 2003a), this presumably does not influence the results. Both in the results section and in the Appendixes, the vowels are indicated in Arpabet notation. Table 15, in Appendix III, shows the IPA-Arpabet conversion for the vowels of this study.

2.3 RECORDING EQUIPMENT

Speech recordings were made with a sampling rate of 44.1 kHz through Saffire Pro multi-channel AD converter and preamplifier, using Audacity software (see http://audacity.sourceforge.net/) for recording. For editing, PRAAT was used (Boersma and Weenink 2009). Speech was recorded via 7 microphones (Sennheiser ME64/K6p) placed in different locations, namely in front of the speaker,

behind, left, front-left, right, front-right, above, and also via a close-talking microphone (Sennheiser Headset HSP 2ew). The data from multiple microphones are intended for a different unrelated project on automatic speaker recognition from longitudinal data. For the present study, the close-talking microphone (channel 1) and channel 2 (in front of the speaker, as a back-up) were used.

2.4 Procedure and data collection

The students were recorded two times: at the beginning (September 2010) and at the end (May 2011) of their first year. All recordings took place in a quiet office room at UCU. Participants were asked to read aloud several texts sentences (see Appendix I). Participants were encouraged to talk as natural, and with as few mispronunciations as possible. When participants made a mistake, the experimenter could ask the participant to read a certain sentence or passage again. After the reading part, participants were asked to speak spontaneously for another 9 minutes. The latter recordings were not used in the present study. Overall, the actual recording took about 15-25 minutes per participant. After the first recording session, participants were asked to fill in a questionnaire about their language background. Participants received 10 euro for each session.

2.5 Forced Alignment: P2FA

Because of the large amount of recorded speech, the segmenting of the speech stream was done using forced alignment software. For this study, the Penn Phonetics Lab Forced Aligner Toolkit (P2FA) was used to segment the speech stream (Yuan and Liberman 2008). The P2FA can automatically segment words and phonemes in a continuous speech stream when it is fed with an orthographical transcript of the speech. The acoustic models of the P2Fa are trained on the SCOTUS corpus, which in full includes more than 50 years of oral arguments from the Supreme Court of the United States. The P2FA uses the CMU American English Pronouncing Dictionary (see http://www.speech.cs.cmu.edu/cgi-bin/cmudict/) for the alignment of speech to text (via a transcription of the speech, see below).

The alignment was done in several steps. First, each sound file was inspected by the experimenter and errors and mispronunciations were deleted. The repaired utterance was put into the slot of the deleted utterance. Second, the modified recording and its transcript were put together and run through the P2FA software. The output of the P2FA was a PRAAT Textgrid. Third, after the alignment, the Textgrid together with the sound file were manually checked on the accuracy of word-boundaries. This operation aimed at verifying that the forced aligner indeed had segmented correctly. If a target word was not segmented as intended, then both word and phoneme boundary were set manually. If a target word was segmented correctly, phoneme boundaries were not inspected. This procedure ensured that the observed variation in segment duration originates either from within or between speakers' differences (target factors) or from within-word phoneme segmenting inaccuracy (noise). It prevented variation due to inaccurate word-segmentation. Lastly, with a special script (adopted from: www.let.uu.nl/~Hugo.Quené/personal/tools/tg2df.praat), the Textgrid was converted into a simple text file, which listed the on- and offset of each word and phoneme together with its duration.

3. RESULTS

Three mixed effect analyses were performed on the data using IBM SPSS 18.0 statistical software. See for more information about this statistical procedure: Baayen, Davidson, and Bates 2008; Quené and van den Bergh 2004; Quené and van den Bergh 2008. Durations smaller than 0.02 s and bigger than 0.25 s were excluded from all analyses.

Section 3.1 discusses the first analysis in which session I of the Dutch speakers of English (DSE-I) is compared to the control group (NSE). To establish if the Dutch speakers of English changed their temporal pattern during their first year on campus section 3.2 compares the results between session I and session II of the Dutch speakers of English (DSE-I and DSE-II). Section 3.3 compares the results of sessions II (DSE-II) to the control group (NSE). Section 3.4 investigates if speech rate differs between groups and sessions. Section 3.5 describes other effects on vowel durations. In all sections, the difference in mean vowel duration between groups is considered meaningful (indicated with an exclamation mark **!**) if the mean of one group, plus or minus 2 times the largest standard error, did not overlap the mean duration of the other group. In Appendix IV lists the estimated marginal means and displays figures for the effects in more detail.

3.1 COMPARISON SESSION I – CONTROL GROUP

To compare the Dutch speakers of English of session I (DSE-I) with the group of native English speakers (NSE) a mixed effect analysis was performed with vowel duration as dependent variable, subject as random factor and group (DSE-I and NSE), vowel identity (AE, AH, EH, IH, UH, AA, AO, AY, EY, IY, UW), final consonant (fortis and lenis) and position (non-final, phrase-final and sentence-final) as fixed factors. This section focuses on group effects.

Group by vowel by consonant. The three-way interaction group by vowel by final-consonant was significant ($F(9, 2961.250)=3.947$, $p<.001$). Table 1 displays estimated marginal means with standard errors per group of this interaction. See also Figure 1 and 2 in Appendix IV. DSE-I and NSE show

similar durations on the vowels AE-lenis, AH, EH, IH, UH, AA-fortis, EY, IY and UW-lenis. DSE-I have shorter (-) durations than NSE for the vowels AE-fortis, AA-lenis and AO-lenis and longer (+) durations for the vowels AO-fortis, AY-fortis, AY-lenis and UW-fortis. Target words for AE-fortis, AA-lenis and AO-lenis appear in sentence-final position; therefore, vowels in these words are lengthened. This final lengthening is indeed done by NSE, but not by DSE-I. For the vowels AY-fortis, AY-lenis and UW-fortis, DSE-I have longer durations than NSE. Especially tense vowels seem to be difficult for DSE-I.

TABEL 1: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER VOWEL BY CONSONANT FOR THE GROUPS DSE-I AND NSE.

	Vowel	Final consonant	DSE-I *Mean (SE)*	NSE *Mean (SE)*	Difference DSE-I NSE
Lax	**AE**	**lenis**	.132 (.006)	.125 (.012)	
		fortis	**.092 (.004)**	**.121 (.008)**	**! -**
	AH	**lenis**	.129 (.006)	.114 (.013)	
		fortis	.071 (.004)	.080 (.009)	
	EH	**lenis**	.146 (.004)	.139 (.010)	
		fortis	.093 (.004)	.095 (.008)	
	IH	**lenis**	.063 (.004)	.071 (.009)	
		fortis	.085 (.006)	.067 (.012)	
	UH	**lenis**	.098 (.004)	.090 (.009)	
		fortis	.083 (.004)	.071 (.009)	
Tense	**AA**	**lenis**	**.138 (.004)**	**.175 (.009)**	**! -**
		fortis	.097 (.004)	.112 (.008)	
	AO	**lenis**	**.119 (.003)**	**.135 (.006)**	**! -**
		fortis	**.164 (.006)**	**.112 (.012)**	**! +**
	AY	**lenis**	**.121 (.003)**	**.103 (.007)**	**! +**
		fortis	**.156 (.004)**	**.135 (.008)**	**! +**
	EY	**lenis**	.121 (.003)	.110 (.006)	
		fortis	.142 (.004)	.128 (.007)	
	IY	**lenis**	.158 (.003)	.157 (.007)	
		fortis	.132 (.004)	.139 (.008)	
	UW	**lenis**	.055 (.006)	.049 (.012)	
		fortis	**.100 (.004)**	**.078 (.009)**	**! +**

Group by vowel. The interaction group*vowel was also significant ($F(10, 2961.398)=6.555$, $p<.0001$). Table 2 displays estimated marginal means with standard errors per group of this interaction. See also Figure 4 in Appendix IV. DSE-I and NSE have similar durations for all lax

vowels (AE, AH, EH, IH and UH), and for the tense vowels AO and IY. For the tense vowels AY, EY and UW, DSE-I have longer durations than NSE, while on the vowel AA, DSE-I have shorter durations. The deviant durations on the vowels AA, AY and UW can be explained by the previously discussed group by vowel by consonant interaction.

TABEL 2: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER VOWEL FOR THE GROUPS DSE-I AND NSE.

Vowel		DSE-I *Mean (SE)*	NSE *Mean (SE)*	Difference DSE-I NSE
Lax	**AE**	.105 (.004)	.122 (.007)	
	AH	.100 (.004)	.097 (.008)	
	EH	.120 (.003)	.117 (.007)	
	IH	.074 (.004)	.069 (.008)	
	UH	.088 (.004)	.077 (.007)	
Tense	**AA**	**.117 (.003)**	**.143 (.007)**	**! -**
	AO	.130 (.003)	.129 (.006)	
	AY	**.139 (.003)**	**.119 (.006)**	**! +**
	EY	**.135 (.003)**	**.122 (.006)**	**! +**
	IY	.145 (.003)	.148 (.006)	
	UW	**.085 (.004)**	**.068 (.008)**	**! +**

Group by consonant. On the fortis-lenis contrast as well, both groups have different vowel durations, as can be seen by the significant group*consonant interaction ($F(1, 2961.535)=6.017$, $p=.014$). Table 3 displays estimated marginal means with standard errors per group of this interaction. See also Figure 5 in Appendix IV. According to the criterion of meaningful differences, no differences between groups were found. However, the difference in duration between vowels before lenis consonants and vowel before fortis consonants is much smaller for DSE-I (.014 s) than for NSE (.022 s.).

TABEL 3: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER CONSONANT FOR THE GROUPS DSE-I AND NSE.

Final consonant	DSE-I *Mean (SE)*	NSE *Mean (SE)*	Difference DSE-I NSE
lenis	.122 (.001)	.126 (.005)	
fortis	.108 (.001)	.104 (.005)	

Non-significant group effects. No main effect for group was found (F(1, 63.987)=.287, p=.594). The interaction group*position was not significant (F(2, 2961.362)=1.295, p=.274), nor was the interaction group*vowel*position (F(7, 2961.353)=1.855, p=0.073) and the interaction group*consonant*position (F(2, 29621.890)=.722, p=.486). The four-way interaction group*vowel*consonant*position was also non-significant (F(1, 2962.426)=.043, p=.836).

Discussion. The Dutch speakers of English of session I have deviant vowel durations in respect to vowel identity and the fortis-lenis contrast. Especially tense vowels seem to be affected. In most cases, the Dutch speakers of English have longer durations than the native speakers. Longer durations may have to do with slower speech rates, which are often found in L2 speech (De Jong et al. *in press;* Trofimovich and Baker 2006). For the vowels AA-lenis, AE-lenis and AO-lenis, Dutch speakers of English have shorter durations than the native speakers. Target words of these vowels appear in sentence-final position. It may be that DSE-I have an additional cognitive load imposed by working in L2, and therefore fewer resources available to lengthen durations in final positions (Fehringer and Fry 2007). For the vowel AO-fortis, Dutch speakers of English had longer durations than the native speakers. This may be due to the fact that initial th-sound of the target word 'thought' is absent in Dutch (Collins and Mees 2003a) and therefore difficult to produce for Dutch speakers of English. Additionally, Dutch speakers of English show smaller durational differences than the native between vowels with fortis and lenis endings, indicating that they are aware of this word-final contrast, but unable to realize it natively. Surprisingly, mostly tense vowels seem to be difficult for Dutch speakers of English. Why this is the case remains to be investigated, but it may have to do with the simple fact that tense vowels have overall longer durations and are thus intrinsically more flexible than lax vowels.

3.2 Comparison Session I – Session II

For the comparison between the Dutch speakers of English of session I (DSE-I) and the same speakers of session II (DSE-II), a mixed effects analysis was performed with duration as dependent

variable, subject as random variable, session (DSE-I and DSE-II), final consonant (fortis and lenis), vowel identity (AE, AH, EH, IH, UH, AA, AO, AY, EY, IY, UW) and position (non-final, phrase-final and sentence-final) as fixed factors. Session was indicated as a repeated measure. The native speakers of English were excluded from this analysis. Again, meaningful differences are indicated with an exclamation mark (!). This section focuses on between-sessions effects.

TABEL 4: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER VOWEL BY CONSONANT PER SESSION.

	Vowel	Final consonant	DSE-I *Mean (SE)*	DSE-II *Mean (SE)*	Difference DSE-I DSE-II
Lax	**AE**	**lenis**	.132 (.006)	.126 (.006)	
		fortis	.092 (.004)	.092 (.004)	
	AH	**lenis**	**.129 (.006)**	**.081 (.007)**	**! -**
		fortis	.071 (.004)	.072 (.005)	
	EH	**lenis**	**.146 (.004)**	**.128 (.005)**	**! -**
		fortis	.093 (.004)	.087 (.004)	
	IH	**lenis**	.063 (.004)	.057 (.005)	
		fortis	.085 (.006)	.075 (.006)	
	UH	**lenis**	.098 (.004)	.090 (.005)	
		fortis	**.083 (.004)**	**.072 (.005)**	**! -**
Tense	**AA**	**lenis**	.138 (.004)	.145 (.005)	
		fortis	.097 (.004)	.110 (.004)	
	AO	**lenis**	.119 (.003)	.121 (.004)	
		fortis	.164 (.006)	.156 (.006)	
	AY	**lenis**	**.121 (.003)**	**.112 (.004)**	**! -**
		fortis	**.156 (.004)**	**.145 (.004)**	**! -**
	EY	**lenis**	**.121 (.003)**	**.111 (.004)**	**! -**
		fortis	.142 (.004)	.141 (.004)	
	IY	**lenis**	**.158 (.003)**	**.150 (.004)**	**! -**
		fortis	.132 (.004)	.125 (.004)	
	UW	**lenis**	.055 (.006)	.047 (.006)	
		fortis	.100 (.004)	.095 (.005)	

Session by vowel by consonant. The tree-way interaction session*vowel*consonant was significant ($F(9, 2048.067)=2.231$, $p=.018$). Table 4 displays estimated marginal means with standard errors per session for this interaction. See also Figure 1 and 2 in Appendix IV. In session II, the DSE-II have shorter durations than session I on the vowels AH-lenis, EH-lenis, UH-fortis, AY-fortis, AY-lenis, EY-lenis and IY-lenis.

Session by vowel by position. The three-way interaction session*vowel*position was significant (F(7, 2056.838)=3.126, p=.003). However, due to the limited amount of data, this interaction will not be discussed here. For more information about this interaction, see Appendix IV.

TABEL 5: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER CONSONANT BY POSITION PER SESSION.

Final consonant	Position	DSE-I *Mean (SE)*	DSE-II *Mean (SE)*	Difference DSE-I DSE-II
lenis	**non-final**	**.101 (.001)**	**.096 (.002)**	**! -**
	phrase-final	**.155 (.003)**	**.146 (.003)**	**! -**
	sentence-final	**.142 (.003)**	**.130 (.003)**	**! -**
fortis	**non-final**	.103 (.001)	.099 (.002)	
	phrase-final	**.119 (.002)**	**.114 (.002)**	**! -**
	sentence-final	**.101 (.006)**	**.131 (.006)**	**! +**

Session by consonant by position. The three-way interaction session*consonant*position was also significant (F(2, 2079.914)=8.003, p<.0001). Table 5 displays estimated marginal means with standard errors per group of this interaction. See also Figure 3 in Appendix IV. Again, vowel durations in session II are generally shorter than in session I. Only vowels before fortis consonants in sentence-final position are longer in session II than in session I.

TABEL 6: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER VOWEL PER SESSION.

Vowel		DSE-I *Mean (SE)*	DSE-II *Mean (SE)*	Difference DSE-I DSE-II
Lax	**AE**	.105 (.004)	.103 (.004)	
	AH	**.100 (.004)**	**.076 (.004)**	**! -**
	EH	.120 (.003)	.108 (.004)	
	IH	.074 (.004)	.066 (.004)	
	UH	**.088 (.004)**	**.078 (.004)**	**! -**
Tense	**AA**	.117 (.003)	.127 (.004)	
	AO	.130 (.003)	.130 (.004)	
	AY	.139 (.003)	.128 (.003)	
	EY	.135 (.003)	.131 (.003)	
	IY	.145 (.003)	.138 (.003)	
	UW	.085 (.004)	.079 (.004)	

Session by vowel. The interaction session*vowel was significant (F(10, 2054.517)=5.282, p<.0001).

Table 6 (previous page) displays estimated marginal means with standard errors per group of this interaction. See also Figure 4 in Appendix IV. Durations for the vowels AH and UH of session II are shorter than those in session I.

TABEL 7: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER CONSONANT PER SESSION.

Final consonant	DSE- session I *Mean (SE)*	DSE- session II *Mean (SE)*	Distance DSE-I DSE-II
lenis	**.122 (.001)**	**.115 (.001)**	**! -**
fortis	.108 (.001)	.106 (.003)	

Session by consonant. The interaction session*consonant was also significant ($F(1, 2094.425)=14.724$, $p<.0001$), see Table 7 for estimated marginal means with standard error for this interaction. See also Figure 5 in Appendix IV. For lenis consonants, DSE-II have shorter durations than DSE-I. For fortis consonants, DSE-I and DSE-II have similar durations. Also, the durational difference between vowels before lenis consonants and fortis consonants decreases over sessions (.014 s vs. .009 s).

Session by position. Also the interaction session*position was significant ($F(2, 2063.113)=8.953$, $p<.0001$). Table 8 displays estimated marginal means with standard errors per group of this interaction. See also Figure 6 in Appendix IV. Again, DSE-II have overall shorter durations than DSE-I, except for vowel durations in sentence final position, where vowel durations remain the same over the two sessions. Presumably, previously discussed session by consonant by position interaction contributes to this effect.

TABEL 8: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER POSITION PER SESSION.

Position	DSE- session I *Mean (SE)*	DSE- session II *Mean (SE)*	Distance DSE-I DSE-II
non-final	**.102 (.002)**	**.097 (.003)**	**! -**
phrase-final	**.134 (.003)**	**.126 (.003)**	**! -**
sentence-final	.131 (.003)	.129 (.004)	

Session. The repeated measurements analysis showed a significant effect of session (F(1, 2062.219)=25.157, p<.001), indicating that the two sessions differ significantly. Overall, DSE-II have shorter – Mean (SE) = .110(.001) – vowel durations than DSE-I – Mean (SE) = .115 (.001).

Non-significant session interactions. Only the four-way session*vowel*consonant*position was non-significant (F(1, 2063.916)=1.041, p=.308).

Discussion. After a year on campus the Dutch speakers of English change their temporal pattern. Overall, vowel durations become shorter after a year. Presumably, an increase in fluency and thus speech rate accounts for this observed difference (De Jong et al *in press*). Vowels before lenis consonants appear to be more influenced by this overall shortening than vowels before fortis consonants, but why this is the case remains to be investigated. It may be that vowels before lenis consonants have intrinsically longer durations; therefore they may have had more 'room' for change. Furthermore, Dutch speakers of English increase their durations of vowels before fortis consonants in sentence-final position, suggesting a decrease in cognitive working load when speaking in L2 (De Jong et al *in press;* Fehringer and Fry 2007). Alternatively, this effect may stem from an improved mastering of the English phonology in which final lengthening overrules the shortening before fortis consonants, but overall, the realization of the fortis-lenis contrast remains problematic. The difference between vowels before fortis and lenis consonants decreases instead of increases over a year. This suggests that, although becoming more fluent in L2, the language-specific word-final contrast remains difficult for these highly proficient Dutch speakers of English.

3.3 Comparison Session DSE I and II to the Control group

Vowel durations of Dutch speakers of English differ significantly between sessions. Therefore, both sessions can be compared to the control group NSE. This was already done for DSE-I and NSE in the first analysis (see 3.1). For the comparison between DSE-II and NSE, a mixed effect analysis was

performed with the group (DSE-II and NSE), vowel identity (AE, AH, EH, IH, UH, AA, AO, AY, EY, IY, UW), final consonant (fortis and lenis) and position (non-final, phrase-final and sentence-final) as fixed factors and subject as random factor. Again, vowel duration was the dependent variable.

TABEL 9: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER VOWEL BY CONSONANT FOR THE GROUPS DSE-I, DSE-II AND NSE.

	Vowel	Final consonant	DSE-I *Mean (SE)*	DSE-II *Mean (SE)*	NSE *Mean (SE)*	Difference DSE-I NSE	Difference DSE-II NSE
Lax	**AE**	**lenis**	.132 (.006)	.126 (.006)	.125 (.012)		
		fortis	**.092 (.004)**	**.092 (.004)**	**.121 (.008)**	**! -**	**! -**
	AH	**lenis**	.129 (.006)	**.081 (.007)**	**.114 (.013)**		**! -**
		fortis	.071 (.004)	.072 (.005)	.080 (.009)		
	EH	**lenis**	.146 (.004)	.128 (.005)	.139 (.010)		
		fortis	.093 (.004)	.087 (.004)	.095 (.008)		
	IH	**lenis**	.063 (.004)	.057 (.005)	.071 (.009)		
		fortis	.085 (.006)	.075 (.006)	.067 (.012)		
	UH	**lenis**	.098 (.004)	.090 (.005)	.090 (.009)		
		fortis	.083 (.004)	.072 (.005)	.071 (.009)		
Tense	**AA**	**lenis**	**.138 (.004)**	**.145 (.005)**	**.175 (.009)**	**! -**	**! -**
		fortis	.097 (.004)	.110 (.004)	.112 (.008)		
	AO	**lenis**	**.119 (.003)**	**.121 (.004)**	**.135 (.006)**	**! -**	**! -**
		fortis	**.164 (.006)**	**.156 (.006)**	**.112 (.012)**	**! +**	**! +**
	AY	**lenis**	**.121 (.003)**	.112 (.004)	**.103 (.007)**	**! +**	
		fortis	**.156 (.004)**	.145 (.004)	**.135 (.008)**	**! +**	
	EY	**lenis**	.121 (.003)	.111 (.004)	.110 (.006)		
		fortis	.142 (.004)	.141 (.004)	.128 (.007)		
	IY	**lenis**	**.158 (.003)**	**.150 (.004)**	.157 (.007)		
		fortis	.132 (.004)	.125 (.004)	.139 (.008)		
	UW	**lenis**	.055 (.006)	.047 (.006)	.049 (.012)		
		fortis	**.100 (.004)**	**.095 (.005)**	**.078 (.009)**	**! +**	**! +**

Group by vowel by consonant. The three-way group*vowel*consonant interaction was again significant ($F(9, 2498.175)=3.479$, $p<.001$). Table 9 displays the estimated marginal means and standard errors per group for this interaction. See also Figure 3 and 4 in Appendix IV. Comparing the DSE-I and DSE-II with the native speakers, there appears not to be much change between sessions. Again, DSE-II have deviant durations for the vowels AE-fortis, AA-lenis, AO and UW. Again, mostly on tense vowels DSE-II have deviant durations. However, looking closer at these

vowels, the difference between the native speakers and the Dutch speakers of English decreases over a year. Thus, there seems to be a tendency to move towards the durations of the native speakers. After a year, DSE-II become native-like on the vowel AY-fortis and AY-lenis, while in the first session they did not reach native-like accuracy on this vowel. Unlike DSE-I, DSE-II have, compared to NSE, deviant durations on the vowel AH-lenis. This change in duration of AH-lenis has also been observed in the section 3.2.

TABEL 10: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER CONSONANT BY POSITION FOR THE GROUPS DSE-I, DSE-II AND NSE.

Final consonant	Position	DSE-I *Mean (SE)*	DSE-II *Mean (SE)*	NSE *Mean (SE)*	Difference DSE-I NSE	Difference DSE-II NSE
lenis	**non-final**	0.101 (.003)	0.096 (.002)	0.102 (.005)		
	phrase-final	0.156 (.003)	0.146 (.003)	0.159 (.007)		
	sentence-final	0.141 (.004)	**0.130 (.003)**	**0.151 (.007)**		**! -**
fortis	**non-final**	0.103 (.003)	0.099 (.002)	0.096 (.005)		
	phrase-final	0.119 (.003)	0.114 (.002)	0.118 (.006)		
	sentence-final	0.100 (.006)	0.131 (.006)	0.113 (.012)		

Group by vowel by position. The group*vowel*position interaction was also significant (F(7, 2498.241)=2.115, p=.039), but will not be discussed, as noted before. See Appendix IV for more information about this interaction.

TABEL 11: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER VOWEL FOR THE GROUPS DSE-I, DSE-II AND NSE.

Vowel		DSE- session I *Mean (SE)*	DSE- session II *Mean (SE)*	NSE *Mean (SE)*	Difference DSE-I NSE	Difference DSE-II NSE
Lax	**AE**	.105 (.004)	.103 (.004)	.122 (.007)		
	AH	.100 (.004)	**.076 (.004)**	**.097 (.008)**		**! -**
	EH	.120 (.003)	.108 (.004)	.117 (.007)		
	IH	.074 (.004)	.066 (.004)	.069 (.008)		
	UH	.088 (.004)	.078 (.004)	.077 (.007)		
Tense	**AA**	**.117 (.003)**	**.127 (.004)**	**.143 (.007)**	**! -**	**! -**
	AO	.130 (.003)	.130 (.004)	.129 (.006)		
	AY	**.139 (.003)**	.128 (.003)	**.119 (.006)**	**! +**	
	EY	**.135 (.003)**	.131 (.003)	**.122 (.006)**	**! +**	
	IY	.145 (.003)	.138 (.003)	.148 (.006)		
	UW	**.085 (.004)**	.079 (.004)	**.068 (.008)**	**! +**	

Group by consonant by position. Unlike results of the first analysis, the interaction group*consonant*position was significant (F(2, 2498.611)=4.281, p=.014). Estimated marginal means and standard errors per group for this interaction can be found in Table 10. See also Figure 3 in Appendix IV. Only for lenis consonants in sentence-final position, DSE-II have shorter durations than NSE. For the remaining final consonants by position durations, the groups show similar patterns.

Group by vowel. The interaction group*vowel was significant (F(10, 2498.279)=5.067, p<.001). Estimated marginal means and standard errors per group for this interaction can be found in Table 11. See also Figure 4 in Appendix IV. DSE-II and NSE have similar vowel durations on almost all vowels, except for the vowels AH and AA, on which they have shorter durations than NSE. These vowels are discussed in the previous paragraph under the session*vowel*consonant interaction (See p. 19). DSE-II reached native-like accuracy on the vowels AY, EY and UW, while in session I they still produced deviant durations on these vowels.

Group by consonant. The interaction group*consonant was also significant (F(1, 2498.375)=16.395, p<.001). See Table 12 for estimated marginal means and standard errors per group for this interaction. See also Figure 5 in Appendix IV. DSE-II have shorter durations on lenis consonants than NSE, while DSE-II and NSE have similar durations on fortis consonants. The difference between vowels before fortis and vowels before lenis consonants also decreased over sessions; during session I this difference is .014 s, while during session II this difference is .009 s. Compared to NSE, DSE-II move away from a native-like realization of the fortis-lenis contrast (.009 s vs. .018 s).

TABEL 12: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER CONSONANT FOR THE GROUPS DSE-I, DSE-II AND NSE.

Final consonant	**DSE-I** *Mean (SE)*	**DSE- II** *Mean (SE)*	**NSE** *Mean (SE)*	**Distance DSE-I NSE**	**Distance DSE-II NSE**
lenis	.122 (.001)	**.115 (.001)**	**.126 (.005)**		**! -**
fortis	.108 (.001)	.106 (.003)	.104 (.005)		

Group by position. The interactions group*position was significant (F(2, 2498.249)=5.795, p=.003). Table 13 displays estimated marginal means with standard errors per group for this interaction. See also Figure 6 in Appendix IV. According to the criterion of meaning differences, no differences between groups were found. It may be that criterion was set too strict. Looking at the absolute durations, DSE-II appear to have slightly shorter overall durations than NSE, especially in phrase-final and sentence-final positions.

TABEL 13: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF VOWEL DURATION IN SECONDS PER POSITION FOR EACH GROUP AND SESSION

Position	**DSE-I** *Mean (SE)*	**DSE-II** *Mean (SE)*	**NSE** *Mean (SE)*	**Distance DSE-I NSE**	**Distance DSE-II NSE**
Non-final	.102 (.002)	.097 (.003)	.099 (.005)		
Phrase-final	.134 (.003)	.126 (.003)	.134 (.006)		
Sentence-final	.131 (.003)	.129 (.004)	.142 (.007)		

Non-significant group interactions. There was no main effect for group (F(1, 52.403)=.232, p=.632), nor was the four-way interaction group*vowel*consonant*position significant (F(1, 2499.012)=.069, p=.793)

Discussion. After a year on campus the Dutch speakers of English change their temporal pattern. Generally, vowel durations in session II are shorter than in session I. Compared to native speakers, Dutch speakers of English still show deviant patterns in respect to the fortis-lenis contrast on certain (mostly tense) vowels. On the vowels AE-fortis, AH-lenis, AA-lenis and AO-lenis, Dutch speakers of English have durations shorter than the native speakers. A higher cognitive working load may explain these shorter durations, because the target words of these vowels by consonant all appear in sentence-final position. Apparently, native speakers have more resources available for final lengthening (De Jong et al. *in press;* Fehringer and Fry 2007). For the vowels by consonant AO-fortis, and UW-fortis, Dutch speakers of English have longer durations than native speakers. These may be

explained in terms of slower overall speech rate, which is presumably slower for non-native speakers (De Jong et al. *in press;* Yuan, Liberman, and Cieri 2006). Although Dutch speakers of English still produce deviant durations on the above mentioned vowels by consonant, the Dutch speakers of English tend to move towards a more native-like duration on almost all these vowels. For durations in respect to final consonant by position, Dutch speakers of English resemble the native speakers, except for vowels before lenis consonants in sentence-final position, on which they have shorter durations than the native speakers. This stems from previous discussed effect that Dutch speakers of English produce shorter durations on the vowels AH-lenis, AA-lenis and AO-lenis. Target words of these vowels appear in sentence-final position, indicating that although Dutch speakers become more fluent and native-like, they still have fewer resources available for final lengthening. Speech rate should be taken into account as a possible factor to explain the overall decrease over sessions in overall vowel duration of the Dutch speakers of English. This will be done in the next section.

3.4 SPEECH RATE

To calculate an estimate of the speech rate per group and session, the duration between the words 'sat' and 'youth', both in the text 'the boy who cried wolf' was calculated. This was done by subtracting the offset of 'youth' with the onset of 'sat'. The obtained duration is the time in seconds that a speaker needs to produce the text in-between these words. It is an estimate of speech rate because it is a measure of how long it takes to produce a fixed set of syllables. The obtained duration includes silent intervals and pauses within the text, but not between texts. This duration is an indication of fluency; the shorter the duration, the more fluent (De Jong et al. *in press*). Again a mixed effects analysis was performed, with duration as dependent variable and group (DSE-I, DSE-II and NSE) as fixed factor. Subjects were indicated as random factors. See Table 14 for estimated marginal means with standard errors of this effect.

TABEL 14: ESTIMATED MARGINAL MEANS WITH STANDARD ERRORS OF OVERALL DURATION IN SECONDS FOR THE TEXT 'THE BOY WHO CRIED WOLF' FOR THE GROUPS DSE-I, DSE-II AND NSE.

Overall duration	**DSE-I** *Mean (SE)*	**DSE-II** *Mean (SE)*	**NSE** *Mean (SE)*	**Distance DSE-I NSE**	**Distance DSE-II NSE**
The boy who cried wolf	**96.437 (1.741)**	93.372 (1.771)	**85.338(3.524)**	**! +**	

As predicted, there was a main effect of group (F(2, 41.053)=11.609, p<.0001), with shortest duration for native speakers, intermediate duration for DSE-II, and longest duration for DSE-I. Post-hoc Bonferroni shows that DSE-I differs significantly from NSE - mean difference (SE) =11.099(3.931), p=.020 - and DSE-II - mean difference (SE) =3.065(.746), p=.001. But DSE-II did not differ significantly from NSE – mean difference (SE) =8.034(3.944), p=.140.

Discussion. After a year on campus, the Dutch speakers of English have a higher, more native speech rate. This indicates that speakers became more fluent (De Jong et al. *in press*). The increase of speech rate presumably accounts for some of the observed differences, especially the overall shorter vowel durations of the second recording session.

3.5 OTHER FACTORS ON VOWEL DURATION

As predicted, the factors vowel identity, final consonant and position, as well as their interactions, were highly significant in all analysis. Appendix IV lists these effects in detail.

4. DISCUSSION AND CONCLUSION

The aim of this study was to investigate how the temporal pattern of Dutch speakers of English develops within a year when speakers live in an international setting and speak English as a lingua franca. The Dutch speakers of English were recorded two times: at the beginning and at the end of their first year. Patters of vowel durations of this group were compared between the two sessions and both sessions were compared to vowel durations of native speakers of English. Analyses focused on the durational patterns in respect to three variables: (1) intrinsic vowel identity, (2) word-final consonant (fortis vs. lenis) and (3) position of the target word (non-final, phrase-final or sentence-final).

At the beginning of the year Dutch speakers of English show, compared to native speakers, smaller durational differences between vowels before fortis and vowels before lenis endings, indicating that they are aware of the fortis-lenis contrast, but unable to realize it natively. Overall, these Dutch speakers of English have longer durations than the native speakers, which can be explained by an overall slower speech rate (De Jong et al. *in press;* Yuan, Liberman, and Cieri 2006). For some vowels, all having lenis endings, the Dutch speakers of English have shorter durations than the native speakers. This may be explained by a higher cognitive working load, imposed by speaking in L2, because all target words of these vowels appear in sentence-final position (De Jong et al. *in press;* Fehringer and Fry 2007). Furthermore, especially tense vowels were difficult for the Dutch speakers of English. This may have to do with the intrinsic nature of tense vowels; having overall longer durations and thus more flexibility to be lengthened/shortened.

Comparison between sessions shows that overall vowel durations become shorter after a year. Presumably, an increase in fluency and thus speech rate accounts for this observed difference (De Jong et al *in press*). A increase in overall speech rate has indeed been found in the present study, confirming the idea of improved fluency. Vowels before lenis consonants appear to be more

influenced by this overall shortening than vowels before fortis consonants. Again, this may be because these vowels have intrinsically longer durations and are therefore more flexible to change. Furthermore, Dutch speakers of English increase their durations of vowels before fortis consonants in sentence-final position, also suggesting an decrease in cognitive working load (De Jong et al *in press;* Fehringer and Fry 2007).

After a year on campus, Dutch speakers of English still show deviant patterns in respect to the fortis-lenis contrast on certain vowels. The pattern resembles the pattern found at the beginning of the year, but although Dutch speakers of English still produce deviant durations, they tend to move towards a more native-like duration on almost all these vowels. For the vowel AY they even reach native-like accuracy after a year. Although they become more fluent, the Dutch speakers of English still produce shorter durations on sentence-final items. This indicates that although these L2 speakers are highly proficient in English, they still have fewer resources available when speaking in L2.

Additionally, the aim of this study was to investigate if students converge towards one single temporal pattern. Results do not indicate a decrease in between-speaker variance. However, speakers do change their temporal pattern. In order to establish whether this change is improved proficiency (and thus movement towards a more native temporal pattern) *or* convergence, additional data from other UCU students should be considered. Interestingly, the standard errors of group of the native speakers were generally bigger than those of the Dutch speakers of English, while their group size was smaller. This might have to do with the fact that speakers of the control group originated from different English speaking countries. Seven students were from America, 2 from Canada and 1 from South Africa. English spoken by Dutch speakers may therefore have been more uniform than English spoken by the control group. Tentatively, one might even claim that therefore the Dutch speakers of English show more convergence effects than the control group of native speakers. But, such a conclusion would be too soon; additional research would be needed to establish if UCU

students indeed converge their temporal patterns.

There were, as expected, many variables influencing vowel duration. At least the variables vowel identity, final consonant (fortis or lenis) and the position of the target word within the sentence are important factors. Also the interactions of these variables play an important role in the realization of vowel durations. This supports previous ideas (Van Santen 1992) that vowel durations are influenced by many factors, acting simultaneously and all highly entangled with each other.

This study also found that Dutch speakers of English increase their speech rate, which accounts for the overall shorter duration of the second session. However, speech rate is an extremely complex factor and should be approached with caution. Not only is speaking rate related to proficiency and fluency, speaking rate in L2 is also strongly related to speech rate in L1 (De Jong et al *in press*; Yuan, Liberman, and Cieri 2006). Furthermore, researchers use different measures to assess speech rate. The measure used in this study may not have been the ideal one. De Jong et al. *in press* found that fluency is stronger related to mean syllable duration (excluding pauses) than mean syllable duration (including pauses). The present study used overall duration, and thus includes silent intervals and pauses. As pointed out by (Klatt 1976): "changes in speaking rate exert a complex influence on the durational patterns of a sentence. When speaking slow, a good fraction of the extra duration goes into pauses. On the other hand, increases in speaking rate are accompanied by phonological and phonetic simplifications". Additionally, stressed vowels are less affected by higher speech rate than unstressed vowels (Klatt 1976). Target words in this study were all primary stressed. Taken together, the shorter vowel durations in session II may also be the result of another factor (possibly convergence) than speech rate. Additional research should be conducted to investigate the relation between speech rate and the observed decrease in vowel durations.

There were also some limitations. Target words were not ideally balanced. Not all conditions were equal in size and some factors could not be separated in the current study. This was the case for the

factors final consonant (fortis or lenis) and position (non-final, phrase-final or sentence-final). For example, there were vowels with fortis endings that only appeared in items in sentence-final position. Therefore, these factors were often impossible to separate. Also, one might wonder if the word-initial consonant(s) influenced the results. It has been found that consonants in word-initial position have negligible influence on vowel durations (Peterson and Lehiste 1960). But Van Santen (1992) points out that vowel duration is reduced by 10-20 ms when a vowel was preceded in the same word by a stop-liquid cluster or a fricative-stop-liquid cluster. In the current dataset however, there are not many words that contain these clusters. A design of minimal pairs would thus not have made this study any stronger. Furthermore, the target words would ideally be split into several final-consonant categories; in order to see how different consonant types influence vowel length. Due to the small size of set of target words, this was impossible to realize. But, all factors still contributed significantly to the observed vowel durations, indicating that the effect of these factors is very strong, even in a non-ideal design.

This study did not take socio-phonetic factors into account. From previous studies (Babel 2010; Delvaux and Soquet 2007) it is known that those factors, such as age, sex and role of the speaker, may modulate the convergence effect. Additionally, a factor not accounted for is the role of the experimenter. As shown in Delvaux and Soquet (2007), ambient speech modulates production. In this study, three different experimenters conducted the recordings: one teacher from UCU, presumably speaking UCU English and two from Utrecht University (UU), speaking Dutch accented English. It might be that participants instructed by the UCU-experimenter accommodate more towards the UCU temporal pattern while participants instructed by the UU-experimenters accommodated more towards a Dutch accented temporal pattern. More research would be needed to assess this confound. Vowel durations analyzed in this study originated from speech that was read aloud. This adds an additional working load on the L2 speaker. If the same patterns also hold for spontaneous speech remains to be investigated.

Another confound was the forced-alignment done by the P2FA (Yuan and Liberman 2008). The first issue is that it is unclear how the forced aligner chose vowel boundaries. But, when visually inspecting the alignment in PRAAT, the aligner did not make big errors. To estimate how reliable the P2FA is in setting vowel boundaries, additional research is required which correlates hand-set boundaries with P2FA-set boundaries. Secondly, there was a rounding issue which added some noise to the obtained data. This rounding issue was caused by the frame size of the P2FA, resulting in durations that were multiples of 0.01 - e.g., durations were either .030 or .040, but never .026. Only the manually corrected word boundaries had other durations. This drawback could possibly be overcome by adjusting the script, but due to the timeframe of this study, this was impossible to realize.

In conclusion, after a year in an English speaking environment, Dutch speakers of English change their temporal pattern. They have overall shorter durations than at the beginning of the year, indicating that they became more fluent and proficient. Compared to the native speakers, the Dutch speakers of English, although moving in the direction of the native speakers, still produce deviant durations on the fortis-lenis contrast, indicating that, even with improved fluency and proficiency, this contrast remains difficult to master for L2 speakers. Additionally, Dutch speakers of English show shorter durations than the native speakers on items in sentence-final position. This effect remains present, even after a year of L2 experience. Taken together, these results indicate that the temporal pattern of Dutch speakers develops within a year. Their temporal pattern becomes more native-like, but it still differs from the temporal pattern of the native speakers both in respect to the fortis-lenis contrast and in respect to the amount of final lengthening on items in sentence-final position. The temporal pattern of English is thus, even for highly proficient L2 speakers, difficult to master.

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APPENDIX I: TEXTS AND SENTENCES FOR READING ALOUD

Words in **bold** are the target words which vowel durations will be used in the analyses.

Extract from "The Rainbow Passage". Fairbanks (1960)

When the sunlight strikes raindrops in the **air**, they act as a prism and form a rainbow. The rainbow is a division of **white light** into many beautiful colours. These **take** the **shape** of a **long** round arch, with its path high above, and its two ends apparently beyond the horizon.
There is, according to legend, a boiling **pot** of gold at one end. People **look**, but no one ever finds it. When a **man** looks for something beyond his **reach**, his friends say he is looking for the pot of gold at the end of the rainbow.

Pronunciation Text **From:** the Speech Accent Archive at http://accent.gmu.edu/

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.

The Boy Who Cried Wolf **From:** http://www.storyarts.org/library/aesops/stories/boy.html

There once was a shepherd boy who was bored as he **sat** on the hillside watching the village sheep. To amuse himself he **took** a **great breath** and sang out, "Wolf! Wolf! The Wolf is chasing the sheep!"
The villagers **came** running up the hill to help the boy drive the wolf away. But when they arrived at the **top** of the hill, they found no wolf. The boy laughed at the **sight** of their angry faces.
"Don't cry 'wolf', shepherd boy," said the villagers, "when there's no wolf!" They went grumbling **back** down the hill.
Later, the boy sang out again, "Wolf! Wolf! The wolf is chasing the sheep!" To his naughty delight, he watched the villagers run up the hill to help him drive the wolf away.
When the villagers saw no wolf they sternly said, "**Save** your frightened **song** for when there is really something **wrong**! Don't cry 'wolf' when there is NO wolf!" But the boy just grinned and watched them go grumbling down the hill once **more**.
Later, he saw a **REAL** wolf prowling about his **flock**. Alarmed, he leaped to his **feet** and sang out as loudly as he **could**, "Wolf! Wolf!" But the villagers **thought** he was **trying** to **fool** them again, and so they didn't **come**.
At sunset, everyone wondered why the shepherd boy hadn't returned to the village with their sheep. They went up the hill to find the boy. They found him weeping.
"There really was a wolf here! The flock has scattered! I **cried** out, "Wolf!" Why didn't you come?"
An old man **tried** to comfort the boy as they walked back to the village.
"We'll help you look for the lost sheep in the morning," he said, putting his arm around the **youth**, "Nobody believes a liar...even when he is telling the truth!"

Five Practice Sentences for Reading Aloud From: White and Mattys 2007
1. The supermarket **chain shut** down because of **poor** management.
2. **Much** more money must be donated to **make** this department succeed.
3. In this famous coffee shop they serve the best doughnuts in town.
4. The chairman decided to **pave** over the shopping center garden.
5. The standards committee **met** this afternoon in an open meeting.

APPENDIX II: TARGET WORDS

Target word	Vowel identity	Vowel type	Fortis - lenis	Position
Bob	AA1	Tense	Lenis	Sentence-final
Flock	AA1	Tense	Fortis	Sentence-final
Frog	AA1	Tense	Lenis	Non-final
Pot	AA1	Tense	Fortis	Non-final
Top	AA1	Tense	Fortis	Non-final
Back	AE1	Lax	Fortis	Non-final
Man	AE1	Lax	Lenis	Non-final
Sat	AE1	Lax	Fortis	Non-final
Snack	AE1	Lax	Fortis	Phrase-final
Come	AH1	Lax	Lenis	Sentence-final
Much	AH1	Lax	Fortis	Non-final
Shut	AH1	Lax	Fortis	Non-final
Call	AO1	Tense	Lenis	Non-final
Long	AO1	Tense	Lenis	Non-final
More	AO1	Tense	Lenis	Sentence-final
Small	AO1	Tense	Lenis	Non-final
Song	AO1	Tense	Lenis	Phrase-final
Store	AO1	Tense	Lenis	Sentence-final
Thought	AO1	Tense	Fortis	Non-final
Wrong	AO1	Tense	Lenis	Sentence-final
Cried	AY1	Tense	Lenis	Non-final
Five	AY1	Tense	Lenis	Non-final
Light	AY1	Tense	Fortis	Non-final
Sight	AY1	Tense	Fortis	Non-final
Tried	AY1	Tense	Lenis	Non-final
Trying	AY1	Tense	Lenis	Non-final
White	AY1	Tense	Fortis	Non-final
Air	EH1	Lax	Lenis	Phrase-final
Breath	EH1	Lax	Fortis	Phrase-final
Fresh	EH1	Lax	Fortis	Non-final
Met	EH1	Lax	Fortis	Non-final
Red	EH1	Lax	Lenis	Non-final
Came	EY1	Tense	Lenis	Non-final
Chain	EY1	Tense	Lenis	Non-final
Great	EY1	Tense	Fortis	Non-final
Make	EY1	Tense	Fortis	Non-final
Pave	EY1	Tense	Lenis	Non-final
Save	EY1	Tense	Lenis	Non-final
Shape	EY1	Tense	Fortis	Non-final
Snake	EY1	Tense	Fortis	Phrase-final
Take	EY1	Tense	Fortis	Non-final
Train	EY1	Tense	Lenis	Non-final
Big	IH1	Lax	Lenis	Non-final
Bring	IH1	Lax	Lenis	Non-final
Thick	IH1	Lax	Fortis	Non-final

Target word	Vowel identity	Vowel type	Fortis - lenis	Position
Cheese	IY1	Tense	Lenis	Phrase-final
Feet	IY1	Tense	Fortis	Phrase-final
Meet	IY1	Tense	Fortis	Non-final
Need	IY1	Tense	Lenis	Non-final
Peas	IY1	Tense	Lenis	Phrase-final
Please	IY1	Tense	Lenis	Non-final
Reach	IY1	Tense	Fortis	Phrase-final
Real	IY1	Tense	Lenis	Non-final
Could	UH1	Lax	Lenis	Phrase-final
Look	UH1	Lax	Fortis	Phrase-final
Poor	UH1	Lax	Lenis	Non-final
Took	UH1	Lax	Fortis	Non-final
Fool	UW1	Tense	Lenis	Non-final
Scoop	UW1	Tense	Fortis	Non-final
Youth	UW1	Tense	Fortis	Phrase-final

APPENDIX III: ARPABETH-IPA CONVERSION TABLE

TABEL 15: VOWELS USED IN THIS STUDY IN BOTH IPA AND ARPABET NOTATION

IPA	Arpabet	Type
æ	AE	Lax
ʌ	AH	Lax
ɛ	EH	Lax
ɪ	IH	Lax
ʊ	UH	Lax
ɑ	AA	Tense
ɔ	AO	Tense
aɪ	AY	Tense
eɪ	EY	Tense
i	IY	Tense
u	UW	Tense

APPENDIX IV: ESTIMATED MARGINAL MEANS AND FIGURES

1. ESTIMATED MARGINAL MEANS

Only significant effects and interactions are displayed.
Only effects and interactions that are not discussed in the Results (chapter 3) are displayed.

Mixed effects analysis 1.
Fixed factors: group (DSE-I, NSE), vowel, consonant and position;
Random factor: subjects;
Dependent variable: duration.

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	63.987	1970.462	.000
group	1	63.987	.287	.594
vowel	10	2961.398	78.611	.000
consonant	1	2961.535	75.721	.000
position	2	2961.362	147.875	.000
group * vowel	10	2961.398	6.555	.000
group * consonant	1	2961.535	6.017	.014
group * position	2	2961.362	1.295	.274
vowel * consonant	9	2961.250	17.282	.000
vowel * position	7	2961.353	15.501	.000
consonant * position	2	2961.890	35.542	.000
group * vowel * consonant	9	2961.250	3.947	.000
group * vowel * position	7	2961.353	1.855	.073
group * consonant * position	2	2961.890	.722	.486
vowel * consonant * position	1	2962.426	5.497	.019
group * vowel * consonant * position	1	2962.426	.043	.836

-2 Log Likelihood: -11661.255

Estimates of Covariance Parameters

Parameter		Estimate	Std. Error	Wald Z	Sig.
Residual		.001172	.000030	38.477362	.000000
Intercept	**Variance**	.000185	.000041	4.556207	.000005

Mixed effects analysis 2 (repeated measures).
Fixed Factors: session (DSE-I, DSE-II), vowel, consonant and position;
Random factor: subjects;
Repeated measures: session;
Dependent variable: duration.

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	2422.893	13943.730	.000
session	1	2062.219	25.157	.000
vowel	10	2415.671	107.989	.000
consonant	1	2439.524	28.872	.000
position	2	2422.745	205.939	.000
session * vowel	10	2054.517	5.282	.000
session * consonant	1	2094.425	14.724	.000
session * position	2	2063.113	8.953	.000
vowel * consonant	9	2410.599	35.750	.000
vowel * position	7	2417.431	18.170	.000
consonant * position	2	2432.425	24.309	.000
session * vowel * consonant	9	2048.067	2.231	.018
session * vowel * position	7	2056.838	3.126	.003
session * consonant * position	2	2079.914	8.003	.000
vowel * consonant * position	1	2430.499	9.664	.002
session * vowel * consonant * position	1	2063.916	1.041	.308

-2 Log Likelihood: -17551.506

Estimates of Covariance Parameters

Parameter		Estimate	SE	Wald Z	Sig.
Repeated Measures	**Variance [session II]**	.000494	.000028	17.643093	.000000
	Variance [session I]	.000483	.000027	17.813150	.000000
Intercept	**Variance**	.000841	.000034	25.067673	.000000

Mixed effects analysis 3.
Fixed factors: group (DSE-II, NSE), vowel, consonant and position;
Random factor: subjects;
Dependent variable: duration.

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	52.403	1584.432	.000
group	1	52.403	.232	.632
vowel	10	2498.279	81.313	.000
consonant	1	2498.375	47.803	.000
position	2	2498.249	140.565	.000
group * vowel	10	2498.279	5.067	.000
group * consonant	1	2498.375	16.395	.000
group * position	2	2498.249	5.795	.003
vowel * consonant	9	2498.175	15.869	.000
vowel * position	7	2498.241	13.277	.000
consonant * position	2	2498.611	23.380	.000
group * vowel * consonant	9	2498.175	3.479	.000
group * vowel * position	7	2498.241	2.115	.039
group * consonant * position	2	2498.611	4.281	.014
vowel * consonant * position	1	2499.012	7.611	.006
group * vowel * consonant * position	1	2499.012	.069	.793

-2 Log Likelihood: -9846.432

Estimates of Covariance Parameters

Parameter		Estimate	Std. Error	Wald Z	Sig.
Residual		.001165	.000033	35.341242	.000000
Intercept	**Variance**	.000215	.000051	4.245588	.000022

Estimated Marginal Means per vowel per analysis

	Analysis 1		**Analysis 2**		**Analysis 3**	
vowel	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
AA	.130	.004	.122	.002	.135	.004
AE	.114	.004	.104	.003	.113	.004
AH	.099	.005	.091	.003	.087	.005
AO	.130	.003	.130	.002	.129	.004
AY	.129	.003	.135	.002	.124	.004
EH	.118	.004	.115	.002	.112	.004
EY	.128	.003	.133	.002	.126	.004
IH	.072	.004	.072	.003	.067	.005
IY	.147	.003	.142	.002	.143	.004
UH	.083	.004	.084	.003	.078	.004
UW	.077	.004	.083	.003	.074	.004

Estimated Marginal Means per consonant per analysis

	Analysis 1		Analysis 2		Analysis 3	
consonant	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
lenis consonant	.124	.003	.120	.001	.120	.003
fortis consonant	.106	.003	.107	.001	.105	.003

Estimated Marginal Means per position per analysis

	Analysis 1		Analysis 2		Analysis 3	
position	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
non-final	.101	.003	.100	.001	.098	.003
phrase-final	.134	.003	.131	.002	.130	.003
sentence-final	.136	.004	.131	.002	.135	.004

Estimated Marginal Means per vowel*consonant per analysis

		Analysis 1		Analysis 2		Analysis 3	
vowel	**consonant**	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
AA	**lenis**	.156	.005	.141	.004	.160	.005
	fortis	.104	.004	.103	.003	.111	.005
AE	**lenis**	.128	.006	.129	.005	.125	.007
	fortis	.106	.004	.091	.003	.107	.005
AH	**lenis**	.122	.007	.111	.005	.097	.007
	fortis	.076	.005	.071	.004	.076	.005
AO	**lenis**	.127	.004	.120	.002	.128	.004
	fortis	.138	.006	.161	.005	.134	.007
AY	**lenis**	.112	.004	.117	.003	.107	.004
	fortis	.146	.004	.152	.003	.140	.004
EH	**lenis**	.143	.006	.139	.004	.134	.006
	fortis	.094	.004	.091	.003	.091	.005
EY	**lenis**	.115	.004	.117	.002	.111	.004
	fortis	.135	.004	.142	.003	.134	.004
IH	**lenis**	.067	.005	.062	.004	.064	.005
	fortis	.076	.006	.081	.005	.071	.007
IY	**lenis**	.158	.004	.155	.002	.154	.004
	fortis	.136	.004	.129	.003	.132	.005
UH	**lenis**	.094	.005	.095	.004	.090	.005
	fortis	.077	.005	.079	.004	.072	.005
UW	**lenis**	.052	.006	.052	.005	.048	.007
	fortis	.089	.005	.098	.004	.087	.005

Estimated Marginal Means per vowel*position per analysis

		Analysis 1		Analysis 2		Analysis 3	
vowel	**position**	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
AA	**non-final**	.113	.004	.103	.003	.113	.005
	phrase-final	.	.	.	.	.	.
	sentence-final	.148	.005	.141	.004	.157	.005
AE	**non-final**	.117	.004	.114	.003	.116	.005
	phrase-final	.107	.006	.084	.005	.107	.007
	sentence-final	.	.	.	.	.	.
AH	**non-final**	.076	.005	.071	.004	.076	.005
	phrase-final	.	.	.	.	.	.
	sentence-final	.122	.007	.111	.005	.097	.007
AO	**non-final**	.124	.004	.128	.003	.120	.004
	phrase-final	.143	.006	.133	.005	.147	.007
	sentence-final	.128	.004	.132	.003	.130	.004
AY	**non-final**	.129	.003	.135	.002	.124	.004
	phrase-final	.	.	.	.	.	.
	sentence-final	.	.	.	.	.	.
EH	**non-final**	.086	.004	.084	.003	.083	.005
	phrase-final	.151	.006	.146	.004	.141	.006
	sentence-final	.	.	.	.	.	.
EY	**non-final**	.114	.003	.119	.002	.111	.003
	phrase-final	.157	.006	.163	.005	.157	.007
	sentence-final	.	.	.	.	.	.
IH	**non-final**	.072	.004	.072	.003	.067	.005
	phrase-final	.	.	.	.	.	.
	sentence-final	.	.	.	.	.	.
IY	**non-final**	.113	.004	.109	.003	.111	.004
	phrase-final	.180	.004	.175	.003	.175	.004
	sentence-final	.	.	.	.	.	.
UH	**non-final**	.057	.006	.058	.005	.052	.007
	phrase-final	.095	.004	.097	.003	.091	.005
	sentence-final	.	.	.	.	.	.
UW	**non-final**	.073	.005	.077	.004	.072	.005
	phrase-final	.083	.006	.094	.005	.076	.007
	sentence-final	.	.	.	.	.	.

Estimated Marginal Means per consonant*position per analysis

		Analysis 1		Analysis 2		Analysis 3	
consonant	**position**	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
lenis consonant	**non-final**	.102	.003	.099	.001	.099	.003
	phrase-final	.157	.004	.152	.002	.152	.004
	sentence-final	.146	.004	.137	.003	.140	.004
fortis consonant	**non-final**	.100	.003	.101	.001	.097	.003
	phrase-final	.119	.003	.117	.002	.115	.004
	sentence-final	.107	.007	.114	.005	.122	.007

Estimated Marginal Means per vowel*consonant*position per analysis

			Analysis 1		Analysis 2		Analysis 3	
vowel	**consonant**	**position**	*Mean*	*SE*	*Mean*	*Mean*	*SE*	*Mean*
AA	**lenis consonant**	**non-final**	.123	.006	.114	.005	.128	.007
		phrase-final	.	.	.	.	.	.
		sentence-final	.189	.007	.169	.005	.192	.007
	fortis consonant	**non-final**	.102	.005	.092	.004	.099	.005
		phrase-final	.	.	.	.	.	.
		sentence-final	.107	.007	.114	.005	.122	.007
AE	**lenis consonant**	**non-final**	.128	.006	.129	.005	.125	.007
		phrase-final	.	.	.	.	.	.
		sentence-final	.	.	.	.	.	.
	fortis consonant	**non-final**	.106	.005	.099	.004	.106	.005
		phrase-final	.107	.006	.084	.005	.107	.007
		sentence-final	.	.	.	.	.	.
AH	**lenis consonant**	**non-final**	.	.	.	.	.	.
		phrase-final	.	.	.	.	.	.
		sentence-final	.122	.007	.111	.005	.097	.007
	fortis consonant	**non-final**	.076	.005	.071	.004	.076	.005
		phrase-final	.	.	.	.	.	.
		sentence-final	.	.	.	.	.	.
AO	**lenis consonant**	**non-final**	.110	.004	.094	.003	.107	.004
		phrase-final	.143	.006	.133	.005	.147	.007
		sentence-final	.128	.004	.132	.003	.130	.004
	fortis consonant	**non-final**	.138	.006	.161	.005	.134	.007
		phrase-final	.	.	.	.	.	.
		sentence-final	.	.	.	.	.	.
AY	**lenis consonant**	**non-final**	.112	.004	.117	.003	.107	.004
		phrase-final	.	.	.	.	.	.
		sentence-final	.	.	.	.	.	.
	fortis consonant	**non-final**	.146	.004	.152	.003	.140	.004
		phrase-final	.	.	.	.	.	.
		sentence-final	.	.	.	.	.	.
EH	**lenis consonant**	**non-final**	.102	.006	.103	.005	.099	.007

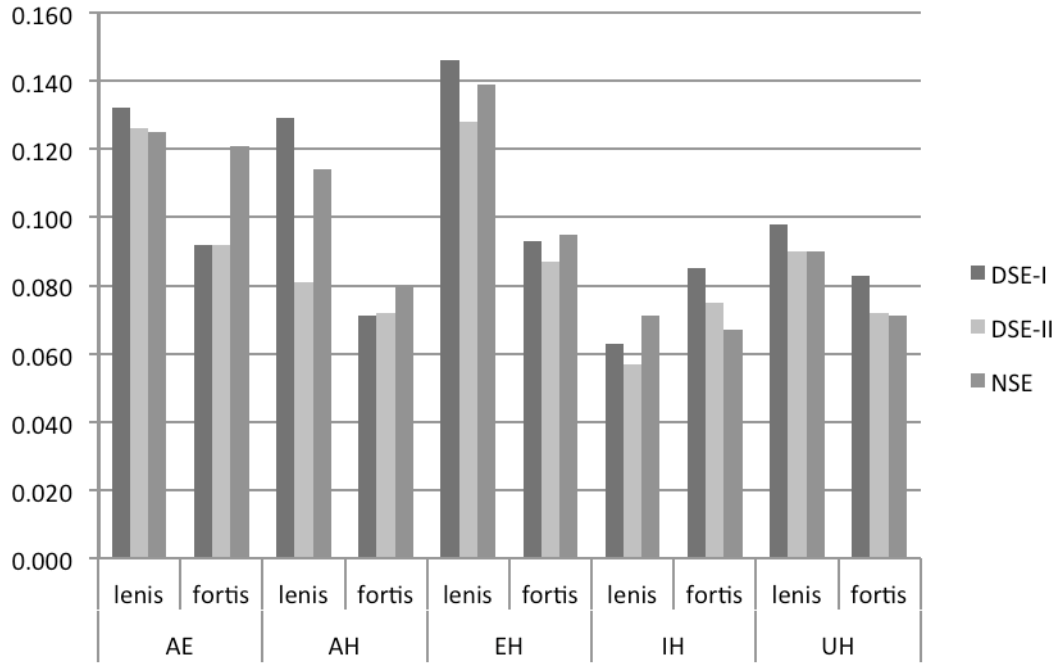
		phrase-final	.184	.009	.175	.005	.169	.009
		sentence-final	.	.	.	.	.	.
	fortis consonant	**non-final**	.070	.005	.066	.004	.068	.005
		phrase-final	.118	.006	.116	.005	.114	.007
		sentence-final	.	.	.	.	.	.
EY	**lenis consonant**	**non-final**	.115	.004	.117	.002	.111	.004
		phrase-final	.	.	.	.	.	.
		sentence-final	.	.	.	.	.	.
	fortis consonant	**non-final**	.113	.004	.120	.003	.112	.004
		phrase-final	.157	.006	.163	.005	.157	.007
		sentence-final	.	.	.	.	.	.
IH	**lenis consonant**	**non-final**	.067	.005	.062	.004	.064	.005
		phrase-final	.	.	.	.	.	.
		sentence-final	.	.	.	.	.	.
	fortis consonant	**non-final**	.076	.006	.081	.005	.071	.007
		phrase-final	.	.	.	.	.	.
		sentence-final	.	.	.	.	.	.
IY	**lenis consonant**	**non-final**	.107	.004	.107	.003	.104	.004
		phrase-final	.209	.005	.203	.004	.203	.005
		sentence-final	.	.	.	.	.	.
	fortis consonant	**non-final**	.119	.006	.111	.005	.117	.007
		phrase-final	.152	.005	.147	.004	.147	.005
		sentence-final	.	.	.	.	.	.
UH	**lenis consonant**	**non-final**	.	.	.	.	.	.
		phrase-final	.094	.005	.095	.004	.090	.005
		sentence-final	.	.	.	.	.	.
	fortis consonant	**non-final**	.057	.006	.058	.005	.052	.007
		phrase-final	.096	.006	.099	.005	.091	.007
		sentence-final	.	.	.	.	.	.
UW	**lenis consonant**	**non-final**	.052	.006	.052	.005	.048	.007
		phrase-final	.	.	.	.	.	.
		sentence-final	.	.	.	.	.	.
	fortis consonant	**non-final**	.095	.007	.103	.005	.097	.007
		phrase-final	.083	.006	.094	.005	.076	.007
		sentence-final	.	.	.	.	.	.

2. FIGURES

2.1 GROUP EFFECTS

Figures in this section are based on estimated marginal means.

FIGUUR 1: MEAN DURATION PER VOWEL*CONSONANT FOR DSE-I, DSE-II AND NSE. THIS FIGURE DISPLAYS THE LAX VOWELS



FIGUUR 2: MEAN DURATION PER VOWEL*CONSONANT FOR DSE-I, DSE-II AND NSE. THIS FIGURE DISPLAYS THE TENSE VOWELS

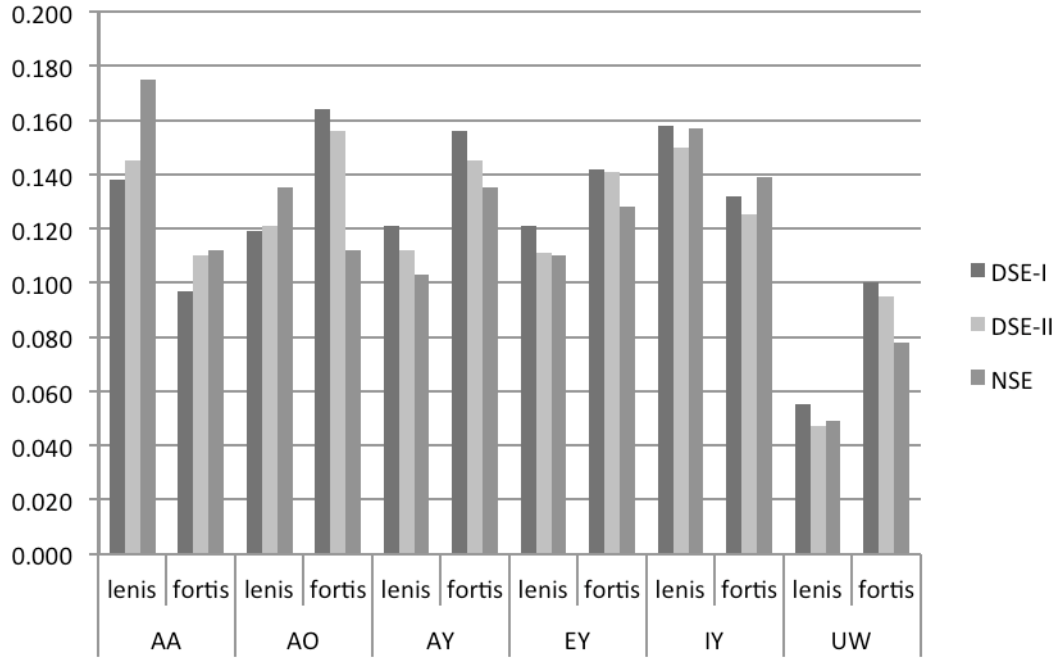


FIGURE 3: MEAN DURATION PER CONSONANT*POSITION FOR DSE-I, DSE-II AND NSE.

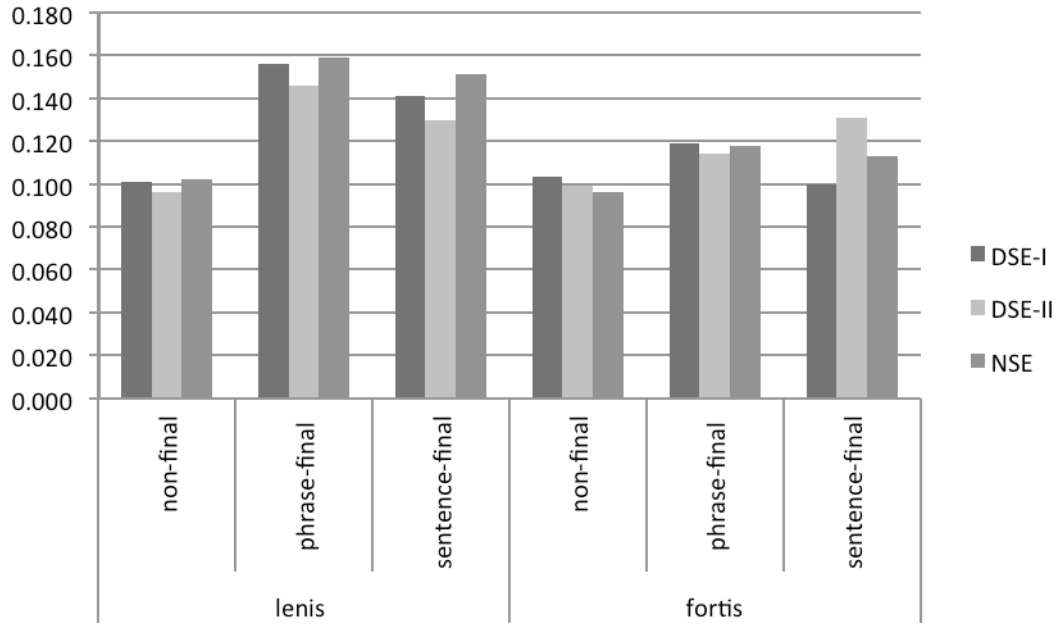


FIGURE 4: MEAN DURATION PER VOWEL FOR DSE-I, DSE-II AND NSE.

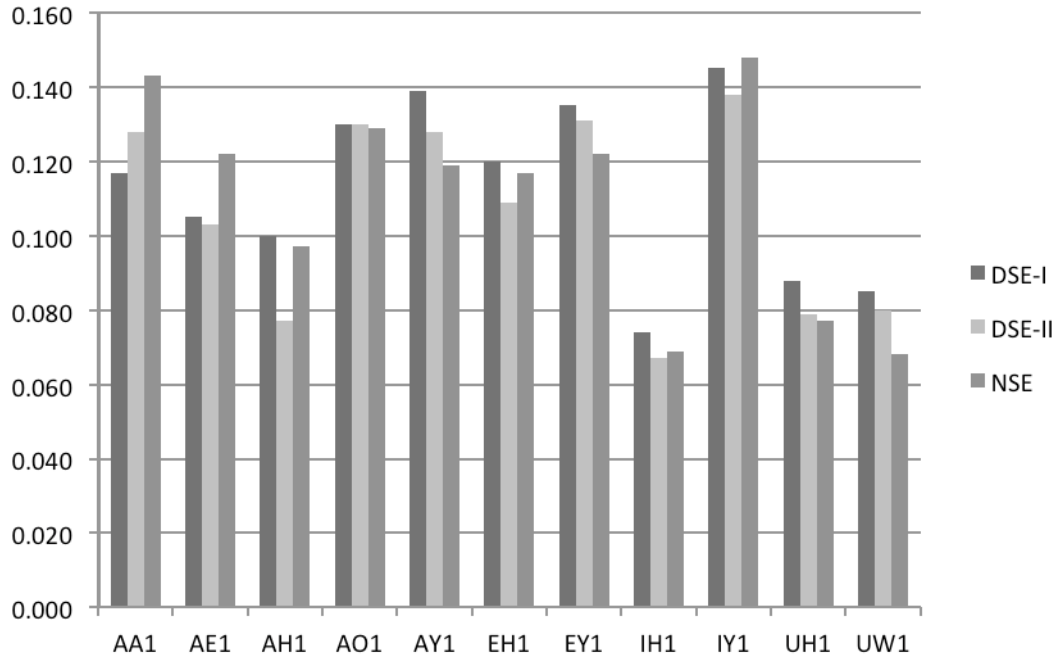


FIGURE 5: MEAN DURATION PER CONSONANT FOR DSE-I, DSE-II AND NSE.

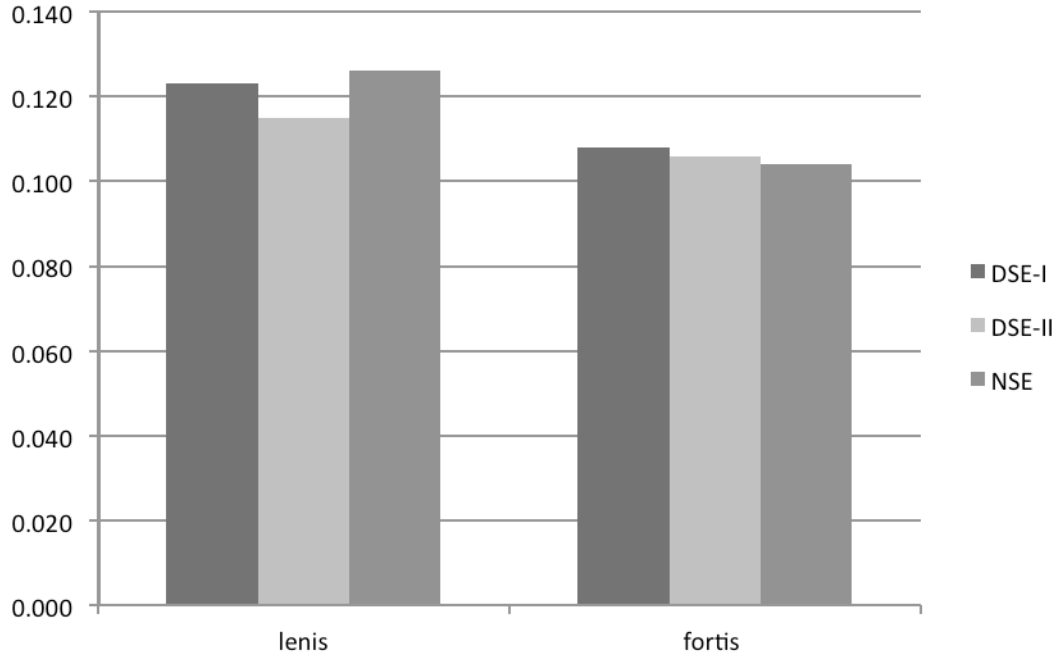


FIGURE 6: MEAN DURATION PER POSITION FOR DSE-I, DSE-II AND NSE.