ISCA Archive
http://www.isca-speech.org/archive

2nd International Conference on Spoken Language Processing (ICSLP 92)
Banff, Alberta, Canada
October 12-16, 1992

LINGUISTIC VERSUS PHONETIC EXPLANATION OF CONSONANT LENGTHENING AFTER SHORT VOWELS: A CONTRASTIVE STUDY OF DUTCH AND ENGLISH

Vincent J. van Heuven

Dept. Linguistics/Phonetics Laboratory, Leyden University
P.O. Box 9515, 2300 RA Leyden, The Netherlands

10.21437/ICSLP.1992-343

Abstract

In Dutch, intervocalic consonants are longer after short vowels than after long vowels. Two explanations for this phenomenon are experimentally tested in this paper. The first is a universal explanation, suggesting that short vowels are abruptly stopped ("checked"), so that the tail-portion of the vowel is traded for longer closure duration. The second is a language specific explanation: in the phonology of Dutch, consonants after short vowels have to be analyzed as geminates; longer consonant duration in this context reflects the underlying geminate status. If the language specific explanation is correct, the lengthening effect should not be found for English, which does not require intervocalic consonants after short vowels to be analyzed as geminates. If the universal phonetic account is true, the consonant lengthening effect should be found in any language, including Dutch and English. We report an experiment set up to choose between these two competing accounts.

I. INTRODUCTION

1.1 A phonetic account of intervocalic consonant duration

Data collected by Nooteboom [1:40] for tri-syllabic Dutch nonsense words (pVpVpV) indicate that [p]-closure durations are about 10 ms longer after short vowels than after long vowels. Nooteboom suggests that this phenomenon should be accounted for in a language universal way, invoking the notions of "fester und loser Anschluss" (close and loose contact), or "scharfer und schwacher Silbenschnitt" or "checked vs. free vowels". These are different names for the same phenomenon, viz., that the transition from a short vowel to a following consonant differs from the transition from a long vowel to a following consonant. Specifically, short vowels are stopped forcefully and abruptly soon after the syllable reaches its peak intensity (the syllable crest), whereas intensity tapers off rather more gradually after the crest for long vowels. A similar account was presented earlier for German by Fischer-Jorgensen [2]. Crucially, Slis [3] found higher electromyographic (emg) activity in the lip-closing movements of [p,b] following Dutch short vowels than after long vowels. Moreover, Slis found stronger emg-activity as the closure command was issued earlier in the syllable, i.e. closer to the syllable crest. This indicates that it takes more effort to produce a consonant immediately after a short vowel than after a long vowel. According to Nooteboom [1:41-42] this accounts for the longer duration of consonants following short vowels. The articulatory closure comes earlier in time and so increases the duration of the closure.

If this account is true, we should find the same consonant lengthening effect after short vowels in other languages with a vowel length contrast. English is very much like Dutch in this respect: both languages distinguish between phonologically long and short vowels. As we shall see in the next section, there are, however, crucial differences in syllable structure between Dutch and English.

1.2 A language specific account of intervocalic consonant duration

In this section we shall provide an alternative account for the intervocalic consonant lengthening effect after short vowels in Dutch. We shall argue that Dutch and English differ crucially in the underlying representation of intervocalic consonants after short vowels. We shall first show that both Dutch and English possess a phonemic vowel length contrast. We shall then offer a partial analysis of the two languages leading to the conclusion that, in Dutch, intervocalic consonants after short vowels are underlyingly represented as geminates. Consonants after long vowels are analyzed as simplex, as is also the case for all intervocalic consonants after any vowel in English, whether long or short. We shall then claim that the extra duration of Dutch intervocalic consonants after short vowels is a surface reflection of their underlying geminate status.

Vowel length contrast in Dutch and English. Dutch and English both distinguish between phonologically long and short vowels. These two sets of vowels have different distributional properties, e.g., short vowels cannot occur in word final position in either language, whereas phonologically long vowels can (cf. 1a-b for Dutch, 2a-b for English), and long vowels cannot be followed by a tautosyllabic velar nasal (indicated by *N* in the examples), but short vowels can (cf. 1c-d, 2c-d). Phonologically short vowels are transcribed with capitals, long vowels are in lower case, and geminated.

(1) Dutch:

(a)		(b)	(c)	(d)	
/vloo/	'flea'	*/vlO/	*/tooN/	/tON/	'tongue'
/staa/	'stand	*/stA/	*/staaN/	/stAN/	'bar'
/zee/	'sea'	*/zI/	*/zeeN/	/zIN/	'sing'

(2) English:

(a)		(b)	(c)	(d)	
/soo/	so	*/sO/	*/sooN/	/sON/	song
/sii/	see	*/sI/	*/siiN/	/sIN/	sing
/see/	say	*/sAE/	*/seeN/	/sAEN/	sang

Minimal coda. Phonologists have recently argued that Dutch does not allow syllables whose rime (i.e., vocalic nucleus plus any following segments) contains only one segment [4,5]. This accounts for the distributional fact of (1b) that syllables cannot end in a single vowel. Consequently, Dutch rimes should at least comprise a long vowel or diphthong (taking up two segmental positions, or two morae) or a short vowel plus a consonant. Given the same distributional pattern we accept this analysis for English as well.

As a consequence of this, we have to assume that the first syllable in Dutch words such as *kapper* /kAp@r/ 'hair dresser' or *modder* /mOd@er/ 'mud' is closed by a consonant. Given the above distributional patterns, the same assumption would have to be made with respect to English words such as *tapping* /tAEpIN/ or *tabbing* /tAEbIN/.

Syllable final devoicing. Dutch, in contrast to English, is a language that devoices obstruents in the syllabic coda [5,6]. That the devoicing rule has the syllable as its domain, rather than the morpheme or word, is shown by the systematic absence of voiced obstruents in coda position in Dutch (3).

(3) Dutch:

/sXIs.maa/	'schism'	*/sXIz.maa/
/prIs.maa/	'prism'	*/prIz.maa/
/Os.lo:/	'Oslo'	*/Oz.loo/

In English there is no final devoicing of obstruents, whether these occur at the end of syllables, morphemes or words.

Regressive assimilation of voice. Observe that the /d/ at the end of the first syllable in Dutch [mOd@r] *modder* 'mud', it is not devoiced, although this is what should happen if devoicing is a syllable final process. Syllable final devoicing can be undone only by the presence of a voiced stop at the onset of the second syllable through regressive assimilation. Consequently, we have to assume the presence of a voiced obstruent in the onset of the second syllable. Moreover, this obstruent has to be identical to the final consonant of the first syllable, or else it would not degeminate towards the phonetic surface. Dutch words such as *modder* /mOd.d@r/ therefore must have a geminate consonant in intervocalic position: the final /d/ in the coda of the first syllable is needed to satisfy the minimal demands for a well-formed coda, the following onset /d/ is necessary to prevent the preceding obstruent from devoicing. Extrapolating from this particular class of words, we now make the generalisation that all intervocalic consonants following a short vowel in Dutch are geminates.

In English, regressive assimilation of voice at word or syllable boundaries always has the effect of devoicing final obstruents under the influence of a following initial voiceless obstruent. It will never be the case in English that an unvoiced final obstruent is given a [+voice] feature due to assimilation to a following initial voiced consonant.

In sum, English differs from Dutch in two crucial aspects: (i) English does not devoice (syllable) final obstruents, and (ii) even if it did, it has no process by which the effects of final devoicing can be undone. As a consequence of this, there is no need to analyze intervocalic consonants after short vowels in English as underlying geminates.

1.3 Predictions

Let us now assume that the primary physical correlate of the phonological contrast between simplex versus geminate consonants, in any language, is the duration of the consonant (sequence). We then predict, from the above contrastive analysis, longer (geminate) duration for intervocalic consonants after short vowels than after long vowels (simplex duration) for Dutch but no such effect of preceding vowel length on the duration of intervocalic consonants for English.

If, on the other hand, Nooteboom's language universal account is true, we should find longer intervocalic consonant duration after short vowels in English as well. The following experiment was set up to allow us to choose between these two competing accounts.

II. METHOD

The following (quasi) minimal word pairs were selected for Dutch and English:

	Dutch C after V-	Dutch C after VV-	English C after V-	English C after VV-
plosive	kipper [kIp@r]	keper [keep@r]	kipper [kIp@r]	caper [keep@r]
	hoppen [hOp@]	hopen [hoop@]	hopping [hOpIN]	hoping [hoopIN]
fricative	rissen [rIs@]	racen [rees@]	kissing [kIsIN]	casing [keesIN]
	troffel [trOf@l]	strofe [stroof@]	coughing [kOfIN]	loafing [loofIN]

Each word was embedded in a short fixed carrier phrase: *Wil je ... eens zeggen* for Dutch, and *Please say ... again* for English. The speech materials were recorded onto audio tape in a sound proofed cabin by five native speakers of Dutch and five native speakers of American English, using professional recording equipment (Studer taperecorder, Sennheiser MKH416 condenser microphone). American speakers pronounced the English words, and Dutch speakers recorded only Dutch words. Each speaker recorded the list of materials three times. Speakers were male university students, between 20 and 25 years of age. The American speakers had arrived in the Netherlands no longer than 6 months before the recordings took place.

The recordings were then stored on computer disk (10 KHz, 12 bit, 4.5 KHz LP). Duration of the intervocalic consonants was measured using a high resolution digital waveform analyzer [7] using visual segmentation criteria as developed and illustrated by [8]. Utmost care was taken to apply these segmentation criteria consistently. Since the target sounds were voiceless obstruents a high degree of reliability can be guaranteed.

III. RESULTS

The dataset nominally comprised 240 consonant durations: 2 consonant types (plosive vs. fricative) * vowel types (front vs. back) * 2 vowel lengths (short vs. long) * 2 languages (Dutch vs. English) * 5 (speakers per language) * 3 (repetitions). One response could not be reliably measured, so that the actual dataset comprised 239 measurement points.

Table 1 presents mean intervocalic consonant duration broken down by language (Dutch vs. English) by vowel length (short vowel vs. long vowel).

Table 1: Mean duration (in ms) of plosives and fricatives after short (V) vs. long (VV) vowels in Dutch and English. Means are based on nominally 30 measurements.

	Dutch C after V	Dutch C after VV	English C after V	English C after VV
plosive	100	96	87	87
fricative	130	125	100	107

For Dutch, the earlier results obtained by Nooteboom for nonsense words are qualitatively replicated [1]. Consonant duration, whether for plosive or for fricative, is about 5 ms longer after a short vowel than after a long vowel, i.e., consonant duration correlates negatively with the phonological length of the preceding vowel. The difference in consonant duration after short vs. long vowels is small but statistically highly significant by a paired t-test run on the vowel cognates, $t(59)=2.43$ ($p=0.009$, one-tailed).

The English data do not conform to this pattern at all. There is no difference in the duration of plosives after short vs. long vowels. Fricatives, however, are 7 ms longer, on average, after a long vowel than after a short vowel. This effect is significant by a paired t-test, but runs counter to any prediction, $t(29)=2.11$ ($p=0.043$, two-tailed).

IV. CONCLUSION AND DISCUSSION

On the basis of Nooteboom's universal account of longer consonant duration after short, or rather checked, vowels we should predict the same consonant lengthening effect for Dutch as for English. This prediction is clearly falsified by the results of our experiment. Nooteboom's earlier results obtained for Dutch nonsense words, were replicated for the Dutch part of our material only: intervocalic consonant duration is slightly longer after short vowels than after cognate long vowels. The results for the English materials, which were comparable to their Dutch counterparts in all relevant aspects, show the opposite effect: intervocalic consonant duration was longer after long vowels than after short vowels. Moreover, this effect was obtained for fricatives only; no effect was found at all for plosives.

Clearly then, we have to conclude that a universal account of consonant lengthening after short vowels, as proposes by Nooteboom, is less than adequate. Rather, it seems that a language specific account is called for. We maintain that the observed facts are best accounted for in terms of differences in the underlying status of intervocalic consonants, which are geminates in Dutch after short vowels and single after long vowels, whereas they are always single segments in English whatever the phonological length of the preceding vowel.

It should be pointed out, finally, that the effects of the underlying difference between single and geminate (or ambisyllabic) consonants on the phonetic realisation are very small. A difference of 5 ms between an underlying single vs. geminate consonant, with base durations above 50 ms, remains below threshold, and will never be communicatively useful. Nevertheless the difference is reliable, and as predicted, so that this type of experiment provides a window on underlying linguistic structure. Although phonological rules are operative in the language that eliminate the simplex vs. geminate contrast in the phonetic surface, some remnant of the underlying difference remains.

Such vestiges of underlying linguistic structure have been reported before. Analysis of German word tokens revealed that the distributions of acoustic parameters are significantly different for underlying voiced vs. voiceless stops, even after neutralisation of the opposition in word-final position (Port & O'Dell [9], and references cited there). The phonological rule describing the phenomenon only predicts a word-final voiceless stop, which preserves none of the original characteristics of a voiced stop. Subsequent perceptual tests revealed that the acoustic differences between the neutralised voiced and voiceless cognates could be discriminated a little above chance (59% correct with chance at 50%). Here the differences may be just audible, but are still too small to be communicatively important.

Acknowledgements

The experiment reported in this paper was run by my student Gwynne Boeskool and Vesna Dragojlv (Erasmus fellow from Novisad University). The basic idea for this research was suggested to me by Lorna Gibb (Sheffield University) as a joint project for the Leyden and Sheffield Linguistics departments.

References

[1] S.G. Nooteboom. Production and perception of vowel duration, Doctoral dissertation, Utrecht University, 1972.

[2] E. Fischer-Jorgensen. "Untersuchungen zum sogenannten festen und losen Anschluss," *Kopenhager germanistischen Studien*, vol. 1, pp. 138-164, 1969.

[3] I.H. Slis. "Articulatory effort and its durational and electromyographical correlates," *Phonetica*, vol. 23, pp. 171-188, 1971.

[4] H.G. van der Hulst. *Syllable structure and stress in Dutch*, Dordrecht: Foris, 1984.

[5] H.G. van der Hulst. "On the formulation of phonological rules," in S. Daalder, M. Gerritsen (eds.): *Linguistics in the Netherlands 1980*. Amsterdam: North-Holland, pp. 1-10, 1980.

[6] H.G. van der Hulst. "Ambisyllabicity in Dutch," in H. Bennis, F. Beukema (eds.): *Linguistics in the Netherlands 1985*. Dordrecht: Foris, pp. 57-66, 1985.

[7] D. Broeder. "SESAM manual," *Report no. 24*, Utrecht: Speech Technology Foundation, 1990.

[8] E.A. van Zanten, L. Damen, E. van Houten. "The ASSP Speech Database," *Report no. 41*, Utrecht: Speech Technology Foundation, 1990.

[9] R.F. Port, M.L. O'Dell. "Neutralization of syllable-final voicing in German," *Journal of Phonetics*, vol. 13, pp. 433-454, 1985.