Hanne Kloots*, Steven Gillis and Sven De Maeyer

Vowel pronunciation in open syllables in spontaneously spoken Standard Dutch: Exploring a phonological constraint in a listening task

Abstract: According to the *Bimoraic Constraint* (Kager 1989) and the *Minimal Rhyme Constraint* (Booij 1995), Dutch syllables by default end in either a tense vowel or a lax vowel followed by a consonant. Syllables ending in a lax vowel do not meet the phonological requirements of a felicitous syllable. The present paper reports on a listening task in which this phonological constraint is explored. Three linguists were asked to categorize 3984 vowels in open syllables in bisyllabic Dutch words with two full vowels (e.g., *globaal* [glo'bal] 'global', *dictee* [dɪk'te] 'dictation'). The source words originated from spontaneously spoken Standard Dutch by 80 Flemish and 80 Dutch teachers of Dutch. The main variables of this study were *stress* (stressed vs. unstressed syllables), *relative position in the word* (first vs. second syllable), *vowel* (/a/-/e/-/i/-/o/) and *country* (Flanders vs. the Netherlands).

The present study did not find conclusive empirical evidence for the phonological constraint at issue. In other words, it was not unusual for Dutch syllables to end in a lax vowel. As expected, vowels in stressed syllables are labeled as tense more often than their unstressed counterparts. More lax realizations were found in the first syllable than in the second, and Flemish vowels were more often categorized as lax than Dutch vowels. The vowel with the lowest *tense*-score was /a/.

Keywords: tense/lax distinction, vowel categorization, Dutch, pluricentric language

DOI 10.1515/ling-2014-0019

***Corresponding author: Hanne Kloots:** Department of Linguistics (CLIPS), University of Antwerp, Prinsstraat 13, 2000 Antwerp, Belgium. E-mail: hanne.kloots@uantwerpen.be
Steven Gillis: Department of Linguistics (CLIPS), University of Antwerp, Prinsstraat 13, 2000 Antwerp, Belgium. E-mail: steven.gillis@uantwerpen.be
Sven De Maeyer: Institute for Education and Information Sciences (EduBROn), University of Antwerp, Prinsstraat 13, 2000 Antwerp, Belgium. E-mail: sven.demaeyer@uantwerpen.be

1 Introduction

The contemporary Standard Dutch[1] vowel system contains seven tense vowels (/a/, /e/, /i/, /o/, /y/, /u/, /ø/) and five lax vowels (/ɑ/, /ɔ/, /ɛ/, /ɪ/, /ʏ/), e.g., Booij (1995) and Gussenhoven (1999).[2] Over the years, the Dutch tense-lax distinction has been described, explained and termed in a number of ways.[3] What all sources seem to agree on, however, is that Dutch syllables cannot end in a lax vowel. In other words, open syllables can only contain tense vowels. In fact, this notion was already put forward by some of the pioneers of Dutch phonology (e.g., van Ginneken 1941; van Wijk 1941). However, until now, this thesis has never been studied thoroughly on the basis of an extensive corpus of present-day spontaneously spoken Standard Dutch by Flemish and Dutch speakers. This study endeavors to fill (at least partially) this void.

1.1 Dutch syllable structure

In order to grasp why a Dutch syllable cannot end in a lax vowel, we need to consider certain principles of Dutch syllable structure (e.g., Kager 1989; Booij 1995; Kooij and van Oostendorp 2003). The syllable is a crucial unit in phonology. It is an important domain for phonological rules (e.g., *final devoicing*) and for constraints concerning the co-occurrence of segments. Syllables are usually described in terms of *onset*, *nucleus* and *coda*. In Standard Dutch the syllable's nucleus is always a vowel. This vowel may be preceded by one or more consonants (= *onset*) and may also be followed by one or more consonants (= *coda*). Together, nucleus and coda constitute the *rhyme* of a syllable. Phonologists agree that the Dutch rhyme consists of no more than three and at least two skeletal positions. Tense vowels (VV) fill two positions and constitute a complete rhyme on their own, e.g., *zie* [zi] ('see') and *ga* [ɣa] ('go'), whereas lax vowels (V) fill only one skeleton position and must therefore always be followed by a consonant, e.g., *zit* [zɪt] ('sit') and *gas* [ɣɑs] ('gas'). Consonants, like lax vowels, fill one position.

Various terms are used to express the observation that the Dutch syllable contains at least two positions. Kager (1989: 192) describes the Dutch rhyme as

1 For an introduction into the history, geography and linguistic structure of Dutch, see De Schutter (1994).

2 Schwa and diphthongs are left out of consideration in this article.

3 For an overview, see for example Moulton (1962) and van Oostendorp (2000, pp. 29–32, 64–76). An overview of the research on the tense-lax distinction carried out at the University of Antwerp can be found in Kloots and Gillis (2011).

"minimally bimoraic", Booij (1995: 25–26) formulates a *Minimal Rhyme Constraint* and differentiates between "at least two X-positions", and Kooij and van Oostendorp (2003: 43) distinguish between at least two time units ("minimaal twee tijdseenheden").

Tense vowels and lax vowels can be distinguished on the basis of distributional features (e.g., Cohen et al. 1959; Moulton 1962; Kager 1989; Booij 1995). For instance, tense vowels can be used before /v/ and /z/ (e.g., *d̲o̲zen* 'boxes' with [o]), but not before /ŋ/ (e.g., *to̲n̲g̲* 'tongue' with [ɔ]). Moreover, tense vowels never appear before consonant clusters consisting of a liquid or nasal + non-coronal consonant. A lax vowel, however, can be used in this position, e.g., *zonk* ('sank') and *wolf* ('wolf'). To this list of distributional characteristics, we can also add the feature under study: tense vowels – like VC patterns and unlike single lax vowels – can appear in syllable final position (e.g., *zi̲e̲* 'I see'). Forms with a lax vowel before /z/ (e.g., *mazzel* 'luck', *puzzel* 'jigsaw puzzle') and a small set of French loan words (e.g., *cachet*, *bidet* with final [ɛ]) are traditionally considered to be exceptions. The same holds for simple past forms with tense /i/ before a final consonant cluster (e.g., *hielp* 'helped', *wierp* 'threw').

1.2 Vowel duration vs. vowel quality

The phonological tense-lax distinction does not correspond to one specific phonetic feature (see also Botma et al. 2012: 275). Tense and lax vowels can both be described in terms of *duration* and *quality*. Most tense vowels are somewhat longer than lax vowels. Vowel quality, for its part, can be explained in terms of, among other things, vowel height, backness and rounding (Ladefoged 2006: 226). Generally, lax vowels have a more central position in the vowel chart than tense vowels (Koopmans-van Beinum 1980; Ladefoged 2006: 94). Since the tense-lax distinction cannot be traced back to one specific, objectively measurable phonetic characteristic, some linguists are rather skeptical about this feature. Lass (1976: 41), for example, calls the tense-lax distinction "a case of The Emperor's New Feature", whereas Lodge (2009: 49) simply calls it a "bogus phonetic feature".

In a listening task it appears to be impossible for listeners to distinguish vowel quality and vowel duration (van Heuven et al. 1986: 227). That is, there is no one-to-one relationship between quality and duration. In other words, there appears to be a " 'clash' between the phonetic and the phonological classification of speech sounds" (Booij 1995: 5). Only four out of seven tense vowels (/a/-/e/-/o/-/ø/) have a long duration. The other tense vowels (/i/-/y/-/u/) do not have a significantly longer duration than their lax counterparts. They only have a

long(er) duration before /r/ (Nooteboom 1972; Koopmans-van Beinum 1980; Adank et al. 2004; Rietveld et al. 2004).

1.3 Violation of the Minimal Rhyme Constraint

The idea that syllables in Dutch cannot end in a lax vowel is found in other Germanic languages as well. For example, word-final stressed syllables in English never end in a lax vowel (Collins and Mees 1999: 89; Ladefoged 2006: 96). Interestingly, Standard Yiddish – closely related to German – lacks a tense-lax distinction (Kleine 2003) and Surinamese Dutch has syllables with a word-final lax vowel, presumably under the influence of the Surinamese lingua franca Sranantongo (de Bies 2009: 12). These findings raise questions on the traditional tense-lax distinction and the *Minimal Rhyme Constraint* in (European) Dutch. Are they both as clear-cut as suggested in the phonological literature? In other words, to what extent can the Dutch *Minimal Rhyme Constraint* be violated?

Remarkably enough, although the *Minimal Rhyme Constraint* is very clear-cut and firmly formulated, there seems to be room for syllable final V's (instead of VV- or VC-patterns) as well. Actually, phonological descriptions of Dutch describe a phenomenon called *vowel shortening*. This term is used when Dutch syllables, for example, end in [ɑ] rather than [a], or in [ɔ] rather than [o].[4] According to the phonological literature, *vowel shortening* is restricted to specific conditions. For example, according to Booij (1995: 136), the vowel of the first syllable (except for /a/) can only be lax if the vowel of the second syllable is reduced to schwa. That is, *politiek* 'politics' may be realized as [poli'tik] or [pɔlə'tik]. Or in Booij's terms:

> Except for /a/ the relevant vowels can only be reduced if they head the first syllable of a word-initial foot with its weak syllable being headed by schwa. In other words, reduction of the second syllable is required, except in the case of /a/. (Booij 1995: 136)

Vowel shortening is typical for the first syllable of a word (Kager 1989; Booij 1995). However, if the vowel of the first syllable bears primary stress (e.g., *fo̲to* ['foto] 'photograph') and/or if it is followed by another vowel (= "hiatus position", e.g., *the̲ater* [te'atər] 'theatre'), it is never realized as a lax vowel.

4 It is important to realize that not every "shortened" vowel also has a shorter duration than the "original" tense vowel. For example, the tense vowel /i/ can be "shortened" to /ɪ/, although in Standard Dutch, both vowels have a short duration – see §1.2. *Vowel shortening* is also called *laxing* and/or *qualitative neutralization* (van Oostendorp 2000; Botma et al. 2012).

Over the past decades, the Dutch *Minimal Rhyme Constraint* has been the subject of several psycholinguistic syllabification experiments (e.g., De Schutter and Collier 1986; Gillis and De Schutter 1996; Schiller et al. 1997). Interestingly, in these psycholinguistic experiments, children as well as adults were found to produce numerous syllables ending in a lax vowel. Moreover, in listening experiments, unstressed tense vowels produced in spontaneous speech were frequently categorized as lax vowels (e.g., Koopmans-van Beinum 1980; van Bergem 1995).

The violations of the *Minimal Rhyme Constraint* found in these experiments, can partially be explained by Kager's clarification that the constraint may be very weak in unstressed syllables (Kager 2003). In fact, tense vowels in unstressed syllables have a fairly short duration, which could cause the vowels to be categorized as lax, e.g., *cadeau* [kɑ'do] ('present'). However, this does not explain why De Schutter and Collier (1986) and Gillis and De Schutter (1996) also found several *stressed* syllables ending in a lax vowel.

To get more insight in the possible deviations of the *Minimal Rhyme Constraint*, it is necessary to study the phenomenon of *vowel shortening* in an extensive corpus of contemporary Standard Dutch. In such research, it is also important to cover the whole Dutch language area. Dutch is a pluricentric language with Netherlandic and Belgian Dutch as its main national varieties (Clyne 1992; Grondelaers and van Hout 2011). These varieties share the same written standard language, but spoken Standard Dutch does not sound identical in both countries. For an overview of recent studies on pronunciation differences, see van Heuven and Van de Velde (2010). However, until now, there are no systematic empirical studies of lax vowels in open syllables, taking into account both national varieties. Our study aims to fill this gap by conducting a listening experiment based on a corpus of spontaneously spoken Standard Dutch from several regions in the Netherlands and Belgium.

Why is it so important to study both Netherlandic and Belgian Dutch? The *Minimal Rhyme Constraint* has its origin in studies, written in the Netherlands. However, there are indications that speakers in the Dutch speaking part of Belgium are violating the *Minimal Rhyme Constraint* in conditions that are not described in the existing phonological studies (e.g., Blancquaert 1936; Leenen 1965; Tops 2003). For example, Flemish speakers would produce word-final /ɑ/s (e.g., *villa* ['vɪlɑ] 'villa'). Furthermore, they would make extensive use of /ɔ/ and /ɛ/ in initial syllables without primary stress (e.g., *politiek* 'politics', *elektriciteit* 'electricity'). Leenen (1965) also observed lax vowels in syllables with main stress (e.g., *foto* ['fɔto] 'photograph', *radio* ['rɑdio] 'radio'). The intuition that Flemish speakers produce more open syllables ending in a lax vowel is also reflected in (normative) Flemish pronunciation guides, e.g., Blancquaert (1957), Mussche (1962), Van Maele (1972) and Timmermans (2008).

2 Method

2.1 Spontaneous speech

The study presented here is based on a corpus of spontaneously spoken Standard Dutch. Spontaneous speech is "the most basic type of communicative use of language" (Rischel 1992: 380). Not only can studies of spontaneous speech shed light on tendencies and ongoing changes in everyday spoken language (e.g., Rischel 1992), they also have relevance to language technology. More specifically, findings from such research may be useful to computational linguists who are working on language recognition and text-to-speech systems (see also Laan 1997; Strik 2001; Ernestus and Warner 2011).

2.2 Informants

The spontaneous speech studied in this paper originates from 160 teachers of Dutch. In a survey by Van de Velde and Houtermans (1999), teachers of Dutch were found to be "model speakers" of Standard Dutch, both in Flanders and in the Netherlands. They are indeed professional speakers of Standard Dutch, which they use on an almost daily basis. On the other hand, their language appears to contain more variation than that of radio presenters, whose speech has been examined thoroughly in earlier studies on pronunciation variation (e.g., Van de Velde 1996). Recent research showed that teachers of Dutch are still considered to be the last "gatekeepers" of the standard language, although regional flavoring is accepted (Grondelaers and van Hout 2010).

The sample studied consisted of 80 Flemish and 80 Dutch teachers of Dutch. Both for Flanders (FL) and for the Netherlands (NL), the sample was stratified for *gender* (2), *age* (2) and *region* (4). In both countries, 40 male and 40 female teachers were selected. Half of those selected were born before 1955, while the other half were born after 1960. The selection of the regions was based on linguistic, socio-economic and geographical criteria (van Hout et al. 1999). In both countries, the economic and cultural center was selected (FL: Antwerp/Brabant, NL: Randstad). These centers are assumed to be pivotal in ongoing changes of the standard language. Next, two peripheral areas were chosen (FL: West Flanders, Belgian Limburg; NL: Groningen/Drenthe, Dutch Limburg). Here, the regional dialects are still fairly prevalent. Finally, an intermediate region was selected (FL: East Flanders, NL: Gelderland/Utrecht). Geographically, the intermediate zones are situated between the center and one of the peripheral regions. From a dialectological point of view, these are transitional areas.

Table 1: Description of the teachers' sample, stratified for country (2), sex (2), age (2) and region (4 × 2)

		Born before 1955		Born after 1960	
		male	female	male	female
Flanders					
Antwerp/Brabant	center	5	5	5	5
East Flanders	intermediate	5	5	5	5
West Flanders	periphery 1	5	5	5	5
Belgian Limburg	periphery 2	5	5	5	5
The Netherlands					
Randstad	center	5	5	5	5
Gelderland/Utrecht	intermediate	5	5	5	5
Groningen/Drenthe	periphery 1	5	5	5	5
Dutch Limburg	periphery 2	5	5	5	5

In every region, two or more middle-sized cities were selected (van Hout et al. 1999).[5] In 1998, all teachers of Dutch working in these cities received an invitation to take part in a sociolinguistic project.[6] The cities were selected on the basis of socio-geographic and dialectological criteria. From a dialectological perspective, the dialect of the cities had to be characteristic for the region as a whole. For the same reason, the dialectal background of the informants was also thoroughly checked: only those who had grown up and were still living in the region concerned were eligible for the study. Since all informants were teachers of Dutch, the socio-economic status of the speakers is more or less constant. Further details on the sampling criteria are provided in van Hout et al. (1999) and Kloots (2008). An overview of the sample is presented in Table 1.

5 The Flemish towns were Lier and Heist-op-den-Berg (Antwerp/Brabant), Tongeren and Bilzen (Belgian Limburg), Ieper en Poperinge (West Flanders), and Oudenaarde and Zottegem (East Flanders). The Dutch towns were Alphen aan den Rijn and Gouda (Randstad), Veenendaal, Ede, Tiel, Culemborg and Elst (Gelderland/Utrecht), Assen, Veendam and Winschoten (Groningen/Drenthe), and Geleen, Sittard and Roermond (Dutch Limburg).

6 This Flemish-Dutch project ("De uitspraak van het Standaardnederlands. Variatie en varianten in Vlaanderen en Nederland", 1998–2001) was carried out at the universities of Antwerp and Nijmegen and sponsored by the Research Foundation – Flanders and the Netherlands Organization for Scientific Research.

2.3 Recordings

The informants were interviewed as part of a sociolinguistic project focusing on the pronunciation of Standard Dutch. The interview consisted of several tasks (e.g., reading a word list, naming objects on pictures). To conclude, at least 15 minutes of spontaneous speech were recorded per interviewee. It is this spontaneous speech that is studied in the present paper.[7] The teachers talked about all kinds of topics, including literature, education, holidays, pets and sports. The interviews were conducted by a young Dutch male researcher in the Netherlands and by a young Flemish female researcher in Flanders. Both interviewers tried to restrict their own input to a minimum, picking up on topics put forward by the teachers as much as possible (i.e., *participant observation*). The interviewers spoke Standard Dutch without a local accent. The interviews were recorded in a quiet room with only the teacher and the researcher present. The recordings were made with a portable Tascam DA-P1 DAT recorder and AKG-C420 headsets with condenser microphones.

2.4 Stimuli

This paper investigates the extent to which vowels in open syllables are realized as lax vowels, despite the *Minimal Rhyme Constraint*. Theoretically, of course, all vowels in open syllables appearing in the teachers' corpus could and should be studied. However, since that corpus encompasses more than 40 hours of speech (160×15 minutes), a selection was made. From the words with *at least one open syllable* only the *bisyllabic* words with *two full vowels* were selected.

The focus on bisyllabic words is motivated as follows. Phonetic experiments have shown that vowel duration depends among other things on the number of syllables in a word (Nooteboom 1972). For example, vowels in initial syllables appear to have a shorter duration depending on the number of syllables. Furthermore, vowels from polysyllabic words appear to have a shorter duration before a stressed syllable than before an unstressed syllable. By focusing on bisyllabic words, the number of syllables is kept constant and, consequently, this factor cannot influence pronunciation. Moreover, the results are easier to interpret, since there is no need to differentiate between syllables with primary and secondary stress (Booij 1995, Rietveld et al. 2004). The vowels studied in this

7 The spontaneous speech of the teachers has also been incorporated into the *Spoken Dutch Corpus*. More information on this corpus can be found in van Eerten (2007) and at <http://tst-centrale.org/> (see "Producten" – accessed 18 July 2014).

paper either bear main stress or they are unstressed.[8] For unstressed syllables, the distance to the syllable with main stress is by definition limited: they are located either directly before or after the stressed syllable.

In this paper, only four of the seven tense vowels are studied, i.e., /a/, /e/, /i/, /o/. The three other tense vowels – i.e., /y/, /u/ and /ø/ – turned out to be quite rare in the corpus.[9] In addition, particular word categories were excluded from the analysis: abbreviations (e.g., *tv* 'television'), acronyms (e.g., *Hema* 'Hollandse Eenheidsprijzenmaatschappij" = name of a Dutch chain of department stores), interjections (e.g., *joepie* 'yippee') and words that have lost their open syllable (e.g., *proces* > [pər'sɛs] 'process') because of metathesis. For more detailed information on the selection of the stimuli, see Kloots (2008).

2.5 Categorization task

The stimuli were labeled ("categorized") by means of the internet application *wwstim*[10], developed by Theo Veenker (Utrecht University – the Netherlands). The listeners performed the task individually, from their own computer and at their own pace. They heard the stimuli in a (different) random order and could replay each stimulus as often as they desired. It was not possible to omit stimuli and, once a stimulus had been labeled, it could not be relabeled. The listeners were three linguists who were familiar with the software and who had participated in similar listening tasks before. The dialectal background of the listeners was identical: they all grew up in the province of Antwerp (Belgium).

For every stimulus, the listeners were asked to choose between the labels *tense*, *tense/lax* and *lax*. The options *tense* and *lax* refer to the two phonological categories discussed in the Introduction. *Tense* refers to /a/, /e/, /i/, /o/, *lax* to /ɑ/, /ɔ/, /ɛ/, /ɪ/. The intermediate label *tense/lax* indicates that the listeners hesitated between these two categories.

When a listener heard a strongly reduced form (e.g., schwa or deleted vowel) or when a stimulus was unintelligible to the listener, the response received the

8 The term "stress" refers to lexical stress.

9 The corpus contained only 396 syllables with final /y/ (of which just one single item with /y/ in the second syllable, that is, *accu* 'battery'), 46 items with final /u/ (e.g., *toerist* 'tourist') and just three with final /ø/ (e.g., *eunuch* 'eunuch'). This finding is not exceptional: studies of phoneme frequencies have shown that /y/, /u/ as well as /ø/ are relatively infrequent in Dutch (e.g., Koopmans-van Beinum, 1980; Luyckx et al. 2007).

10 Information on the software *wwstim* is currently available at http://staff.science.uva.nl/~mnilseno/marie/wwstim-1.4.3/doc/ (accessed 18 July 2014).

Table 2: Absolute number of the vowels in the dataset, analyzed in this study (country, stress, word position)

	1st syllable		2nd syllable		Total
	Flanders	**Netherlands**	**Flanders**	**Netherlands**	
stressed	600 (e.g., *sch**a**duw* 'shadow')	435	156 (e.g., *dict**ee*** 'dictation')	140	1331
unstressed	682 (e.g., *k**o**nijn* 'rabbit')	327	392 (e.g., *act**ie*** 'action')	337	1738
Total	1282	762	548	477	3069

label *other*. Unintelligible words are not uncommon in spontaneous speech, so it was important to offer the listeners "a way out". The listeners were instructed to focus on the first or the second syllable. If they were unable to identify a word, they could not reliably evaluate a specific syllable of the word either. For example, in *papier* ([pa'pir] 'paper') only the first vowel had to be categorized (since this is the only open syllable in the word). After all, when listeners only recognized one vowel in the sound stream, it would not have been clear if their judgment concerned /a/ or /i/. Therefore, the label *other* was called into existence.

As soon as one of the three judgments yielded a label *other*, the stimulus was excluded from the dataset. In other words, we only analyzed stimuli that were labeled as, for example, *tense-tense-tense*, *tense-tense-lax* or *tense-tense/lax-lax*. Our corpus contained 3984 vowels (/a/, /o/, /e/ or /i/) in an open syllable of a bisyllabic word. 3069 of them were categorized as *tense*, *tense/lax* or *lax* by all three judges. These 3069 stimuli were statistically analyzed. Tables 2 and 3 give an impression of the absolute numbers behind the final dataset.

The corpus contained more Flemish vowels than Dutch ones and the first syllable was represented better than the final one (Table 2). There are more unstressed than stressed vowels, except for the first syllable in the Netherlands. Table 3 shows that the four vowels under study are not equally distributed over the two word positions (initial vs. final syllable). There are no word-final unstressed /e/'s. Only two word types have a stressed final /a/ (38x *bijna* 'almost', 1x *Breda*, i.e., the name of a Dutch city).[11]

11 The stressed final syllable of *bijna* is typical for Flanders. In the Netherlands *bijna* is (almost) exclusively pronounced with word-initial stress.

Table 3: Absolute number of each vowel in the dataset, analyzed in this study (vowel, stress, word position)

	syllable	stressed	unstressed	Total
/a/	1st	173 – e.g., *schaduw* ('shadow')	171 – e.g., *balans* ('balance')	703
	2nd	39 – e.g., *bijna* ('almost')	320 – e.g., *villa* ('villa')	
/e/	1st	313 – e.g., *mening* ('opinion')	140 – e.g., *decor* ('decor')	579
	2nd	126 – e.g., *dictee* ('dictation')	0	
/i/	1st	472 – e.g., *typisch* ('typical')	277 – e.g., *minuut* ('minute')	1072
	2nd	12 – e.g., *chemie* ('chemistry')	311 – e.g., *actie* ('action')	
/o/	1st	77 – e.g., *woning* ('house')	421 – e.g., *konijn* ('rabbit')	715
	2nd	119 – e.g., *cadeau* ('present')	98 – e.g., *auto* ('car')	
Total		1331	1738	3069

2.6 Variables and hypotheses

This contribution studies whether the corpus provides evidence of the *Minimal Rhyme Constraint*. Furthermore, it investigates the influence of the following variables: *stress*, *position in the word*, *vowel*, *country*, *age* and *gender*.

2.6.1 General

The *Bimoraic Constraint* (Kager 1989) and the *Minimal Rhyme Constraint* (Booij 1995) predict that Dutch open syllables always end in a tense vowel. This study attempts to find empirical evidence for this constraint.

2.6.2 Stress: stressed vs. unstressed syllable

Experiments by Koopmans-van Beinum (1980), van Bergem (1995), and Rietveld et al. (2004) have shown that unstressed vowels usually have a shorter duration and take a more central position in the vowel chart than their stressed counterparts. Consequently, we expect that when the *Minimal Rhyme Constraint* is violated, the unstressed vowels of the corpus will be categorized as lax more often than their stressed equivalents.

2.6.3 Relative position in the word: first vs. second syllable

This paper focuses on vowels in open syllables, originating from bisyllabic words. In bisyllabic words, hence, two positions may be studied, namely first and second

syllable. According to the *Minimal Rhyme Constraint*, both positions can only contain a tense vowel or a VC-combination. However, when the *Minimal Rhyme Constraint* is violated, we only expect lax vowels in the first syllable (Kager 1989; Booij 1995).

2.6.4 Vowel: /a/ – /e/ – /i/ – /o/

Phonetic perception experiments have also shown that tense vowels originating from fluent speech (especially unstressed vowels in free conversation) are often categorized as their lax counterparts. This certainly holds for /a/, but also for /o/ and /e/ (Koopmans-van Beinum 1980; van Bergem 1995). Based on the phonological literature, we expect unstressed /a/ to be categorized as lax most frequently (Kager 1989; Booij 1995).

2.6.5 Country: Flanders vs. the Netherlands

Traditionally, phonological descriptions do not take into account differences between national varieties. However, there are indications that Flemish speakers produce more syllables ending in a lax vowel than Dutch speakers do. This emerges, for example, from observations by Blancquaert (1936), Leenen (1965) and Tops (2003).

2.6.6 Age

The relation between age and vowel shortening has never been thoroughly studied before. According to de Bot (1985), it is more difficult for older speakers to reach extreme positions in the vowel space. However, all informants were active teachers, aged between 21 and 60 at the time of the recordings. Their articulation could be assumed to be perfectly in order. Therefore, we do not expect the factor *age* to have a statistically significant influence on their vowel pronunciation.

2.6.7 Gender

Research on the relationship between gender and vowel shortening is extremely rare. As long as we lack evidence to the contrary, we expect the variable *gender* to have no significant influence.

2.7 Statistical analysis

The dataset is complex by design. The three main sources of variation that the statistical model should account for are *words, respondents* and *judges*. First, the different words used by the respondents are a source of variation: different words may contribute differently to the observed variation in the population. A second source of variation is the various respondents participating in the study. Finally, there are three judges involved in the judgment task. Therefore, in our analyses we need to take into account the differences between judges as well. Given this complex design, we used the mixed effect-modeling framework to model the data.

The dependent variable is ordinal in nature. The listeners categorized the vowels as "tense", "in between tense and lax" or "lax". Consequently, a linear mixed effects model was not appropriate. The data are modeled in the cumulative link mixed model as implemented in R-package ordinal (Christensen 2011). The model considers three random effects: *judges, words,* and *respondents*.

We start the analyses by modeling a null model that can be written as in equation (1):

$$\begin{aligned} logit(P(Y_i \le j)) &= \theta_j - \mu_1(judge_i) - \mu_2(word_i) - \mu_3(respondent_i) \\ & i = 1, \ldots, n,\ j = 1, 2 \end{aligned} \tag{1}$$

In equation (1) we model the cumulative probability of the *i*th rating falling in the *j*th category or below, where *i* indexes all observations and *j* the three rating possibilities minus 1. $\{\theta_j\}$ are called the threshold parameters (or cut-points). The judge effects, word effects, and respondent effects are taken to be random and assumed to be normally distributed. In order to test whether these random effects in the model are statistically significant we shall rely on a log-likelihood ratio test between the null model including all the random effects and the same model without each of the random terms separately. We shall refer to these models as models 0a–0c.

The first model with fixed effects (Model 1) includes the main effects of the different independent variables (*country, stress, syllable*, and *vowel*), controlling for *age* (young vs. old) and *gender*. This model can be formally written as:

$$\begin{aligned} logit(P(Y_i \le j)) = \theta_j &- \beta_1(country_i) - \beta_2(stress_i) - \beta_3(syllable_i) - \beta_4(vowel\_e_i) \\ &- \beta_5(vowel\_i_i) - \beta_6(vowel\_o_i) - \beta_7(age_i) - \beta_8(gender_i) \\ &- \mu_1(judge_i) - \mu_2(word_i) - \mu_3(respondent_i) \\ & i = 1, \ldots, n,\ j = 1, 2 \end{aligned} \tag{2}$$

In equation (2), the main effects of *country, stress, syllable* and *vowel* are estimated as the parameters β_1 to β_6 respectively.

A second model (Model 2) takes into account the possible interaction effects between country and the different vowel characteristics (*country*stress, country*syllable* and *country*vowel*). Finally, in a third model (Model 3) we add the interaction effects between the different vowel characteristics (*stress*syllable, stress*vowel* and *syllable*vowel*).

3 Results

Table 4 contains the Akaike Information Criterion (AIC) and the likelihood ratio test statistics to compare the different models. Based on these comparisons we can first conclude that removing each of the random effects leads to significant worse model fits. This points to statistical significance of each of the random effects: the categorization of vowels varies from word to word ($\sigma^2 = 4.396$), from speaker to speaker ($\sigma^2 = 0.185$) and from judge to judge ($\sigma^2 = 0.027$). Modeling these random effects proved warranted. The smallest variation is found for the judges, which confirms that, in general, the three listeners agreed on the labels quite well.

Based on the comparison of the different models including the independent variables and interaction terms (Model 1–Model 3), we can conclude that the model including both interactions between country and vowel characteristics and interactions between the different vowel characteristics (Model 3) is significantly better than the more parsimonious Model 1 and Model 2 (see Table 4). The resulting parameter estimates of Model 3 are presented in Table 5 (Main effects) and Table 6 (Interactions).

Table 4: Model comparison statistics

	AIC	Δdf	Δ-2LL	p
Model 0 (all random effects in)	15946.80			
Model 0a: $\mu_1(judge_i)$ out	*15979.68*	*1*	*34.9*	*<0.001*
Model 0b: $\mu_2(word_i)$ out	*18683.62*	*1*	*2739.0*	*<0.001*
Model 0c: $\mu_3(respondent_i)$ out	*16071.44*	*1*	*127.0*	*<0.001*
Model 1	14350.73	8	1612.1	<0.001
Model 2	14278.73	5	82.0	<0.001
Model 3	14163.84	7	128.9	<0.001

3.1 Main effects

In the statistical models, we use a reference category of vowels to compare with another category of vowels. For these analyses, the vowel /a/ produced within an unstressed first syllable by younger male Dutchmen is used as reference category.

Table 5 shows significant main effects for the variables *country*, *stress* and *syllable* (= position in the word). To interpret the effects we have to take into account that, given the parameterization of the model, positive parameter estimates of regression weights (Est.) signify a larger probability to categorize vowels as "lax" rather than "in between lax and tense" and a larger probability to categorize vowels as "in between lax and tense" than "tense" and vice versa. For example, the effect of *country* is 1.22. This means that the thresholds are 1.22 logits higher for Flemish vowels as compared to vowels from the Netherlands. So, Flemish productions of /a/ in first unstressed syllables (= reference category) were more often labeled as lax, whereas similar vowels from the Netherlands were called tense more frequently. The other effects can be interpreted analogously. Stressed vowels are more likely to be categorized as tense than their stressed counterparts ($\beta_2 = -4.047$). Moreover, the first syllable contains fewer tense and more lax vowels than the second ($\beta_3 = -1.554$). Finally, when we look at the individual *vowels*, /e/, /i/ as well as /o/ all appear to be categorized as tense

Table 5: Results of the final model (= Model 3): main effects

	Est.	St. Err.	Est./St.Err.	p
*Thresholds**				
"Tense" | "In between tense and lax"	−3.063	0.287	−10.673	<0.001
"In between tense and lax" | "Lax"	−1.715	0.286	−5.997	<0.001
Regression weights				
β_1 Country (1 = Flanders)	1.222	0.181	−6.755	<0.001
β_2 Stress (1 = stressed)	−4.047	0.293	−13.826	<0.001
β_3 Syllable (1 = second syllable)	−1.554	0.294	−5.292	<0.001
β_4 Vowel /e/	−4.023	0.420	−9.590	<0.001
β_5 Vowel /i/	−2.392	0.289	−8.277	<0.001
β_6 Vowel /o/	−2.396	0.313	−7.644	<0.001
β_7 Age (1 = born before 1955)	−0.139	0.082	−1.704	0.088
β_8 Gender (1 = woman)	0.015	0.081	0.188	0.851

* reference category: Vowel /a/; Age = born after 1960; Country = Netherlands; Gender = male; Stress = unstressed; Syllable = First

Table 6: Results of the final model (= Model 3): interactions

	Est.	St. Err.	Est./St.Err.	p
β_9 Country*Stress	−0.080	0.127	−0.632	0.527
β_{10} Country*Syllable	−0.529	0.132	−4.004	<0.001
β_{11} Country*Vowel /e/	0.377	0.253	1.488	0.137
β_{12} Country*Vowel /i/	−0.803	0.165	−4.860	<0.001
β_{13} Country*Vowel /o/	0.289	0.188	1.539	0.124
β_{14} Stress*Syllable	1.975	0.296	6.682	<0.001
β_{15} Stress*Voc_e	1.052	0.468	2.247	0.025
β_{16} Stress*Voc_i	3.002	0.309	9.736	<0.001
β_{17} Stress*Voc_o	0.936	0.317	2.952	0.003
β_{18} Syllable*Voc_e	0.246	0.468	0.525	0.600
β_{19} Syllable*Voc_i	1.431	0.345	4.145	<0.001
β_{20} Syllable*Voc_o	−0.659	0.342	−1.930	0.054

* reference category: Voc /a/; Age = Young; Country = Netherlands; gender = male; Stress = unstressed; Syllable = First

more often than /a/ ($\beta_4 = -4.023$; $\beta_5 = -2.392$; $\beta_6 = -2.396$). The largest difference is found for /e/. No main effect was found for the variables *gender* and *age*.

3.2 Interactions

Next, we study the interactions between the variables *stress*, *syllable* (= position in the word), *country* and *vowel*. The results of the analysis are presented in Table 6. The estimates of the regression weights in this table should be interpreted analogously as the estimates in Table 5. For example, the significant negative interaction term between *country* and *syllable* ($\beta_{10} = -0.529$) signals that the main effect of *syllable* is –0.529 larger for Flemish spoken vowels. This means that the fact that vowels in the second syllable are more probably classified as "tense" than vowels in the first syllable ($\beta_3 = -1.554$), is more outspoken for Flemish spoken vowels.

To facilitate the interpretation, Figures 1 and 2 contain the estimated probabilities of the judgments in each of the categories (tense, in between, lax), split up by *country, syllable* and *stress*. These figures give a visual impression of the main effects and the interactions of the variables under study.

First, we find a significant interaction between *stress* and *syllable*. We already knew that stressed vowels were more likely to be categorized as tense than unstressed ones. However, the difference between stressed and unstressed vowels is more outspoken in the first syllable than in the second one. In other words,

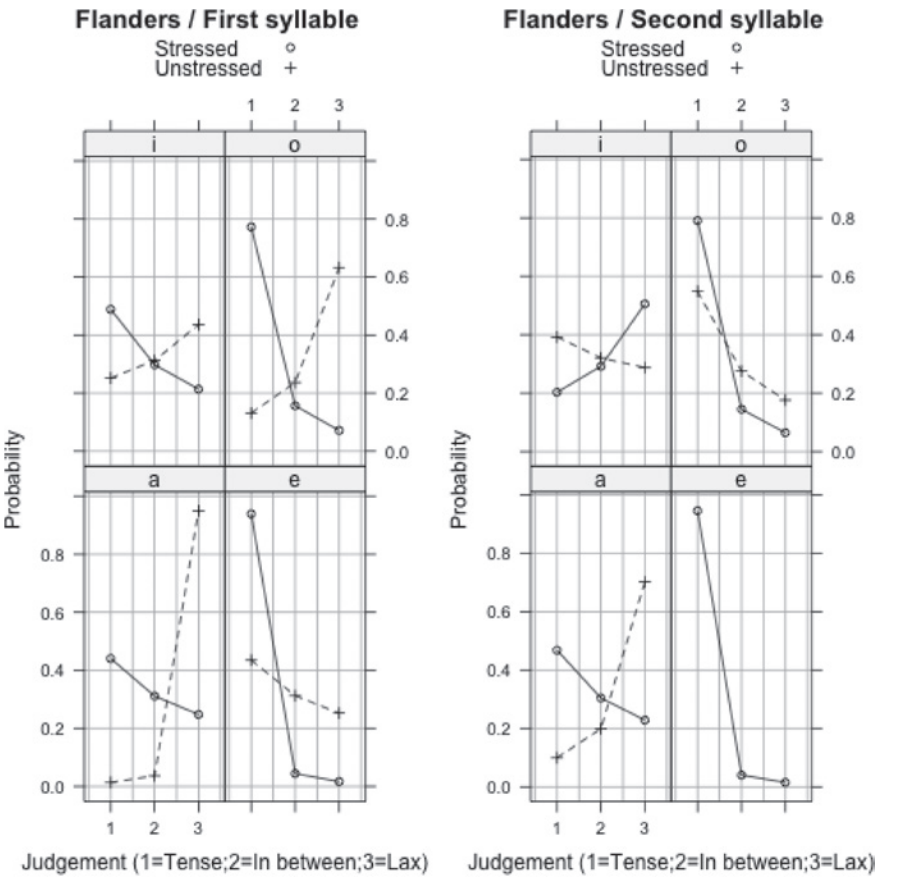

Fig. 1: Estimated probabilities for Flemish vowels based on Model 3

the tendency to be categorized as tense is most outspoken in word-final stressed syllables, whereas unstressed vowels in initial syllables are the least likely to be labeled as tense.

Next, we find a statistically significant interaction between *country* and *syllable*. The Dutch speakers produced more tense vowels than their Flemish counterparts (see *Main effects*). In addition, the difference between both national varieties appears to be stronger for the first syllable than in the second one. Moreover, the difference between the first and the second syllable – with word-final vowels being realized as tense more often – is much more outspoken in Flanders than in the Netherlands. In other words, the chance to be labeled as tense is most apparent for word-final vowels produced in the Netherlands and least apparent for vowels in word-initial syllables produced in Flanders.

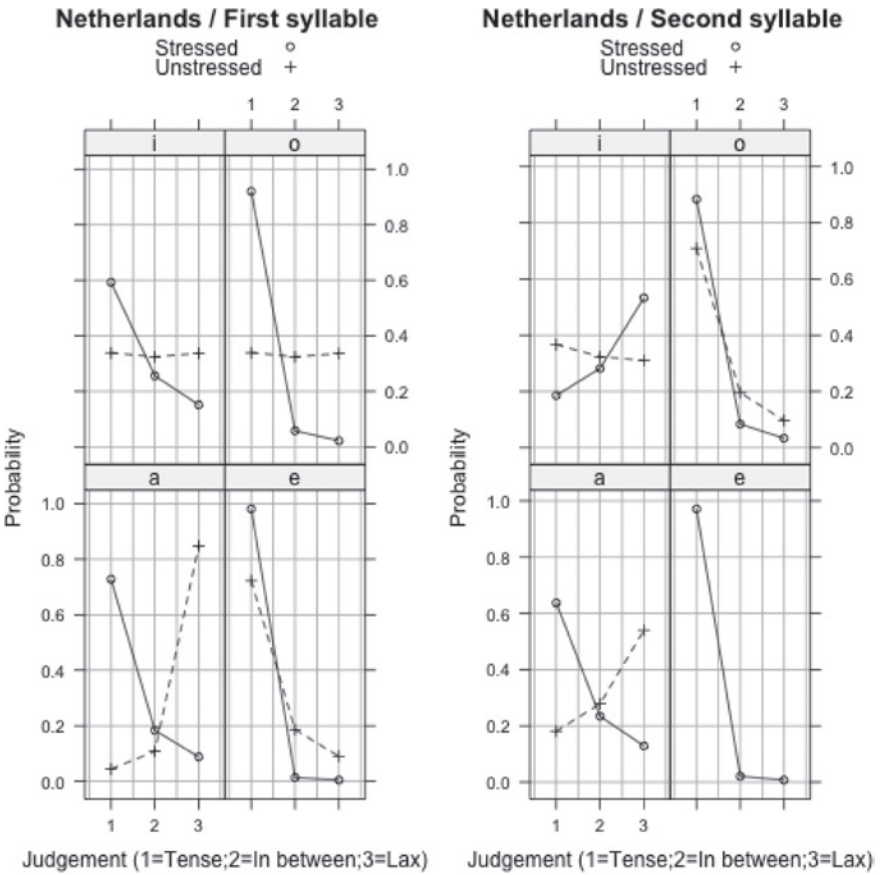

Fig. 2: Estimated probabilities for Dutch vowels based on Model 3

Next, we look at the interaction between *country* and *vowel* (with /a/ as a reference category). First, there is a significant interaction between *country* and /i/. The contrast between /a/ en /i/ (with /i/ being realized as tense more often than /a/ – see *Main effects*) seems to be stronger in Flanders than in the Netherlands. In other words, this interaction shows that both /a/ and /i/ are more often realized as a tense variant in the Netherlands than in Flanders, but for /a/ the contrast between both countries is even larger. Tense vowels appear the least in Flemish /a/'s.

The interaction between *stress* and *vowel* is statistically significant for all vowels under study. Stressed vowels are labeled as tense more frequently than their unstressed counterparts (see *Main effects*). This tendency is larger for /a/

than for the other vowels. In other words, the contrast between /a/ and the other vowels (with /a/ being realized as tense less often) is smaller for the stressed vowels than for the unstressed ones. In sum, unstressed /a/ is the least likely to be realized as tense.

Finally, there is also a significant interaction between *syllable* and the *vowel* /i/. Earlier we found that the second syllable contains more tense vowels than the first one (see *Main effects*). This contrast appears to be more outspoken for /a/ than for /i/. When we look at Figures 1 and 2 (and thus take *stress* into account as well), we discover a similar pattern for /a/ in the first and the second syllable (more tense realizations in stressed syllables, more lax realizations in unstressed syllables), whereas the other vowels show a different pattern in both positions. In the first syllable, /o/, /e/ as well as /i/ mainly show tense vowels, both in stressed and unstressed syllables. In the second syllable, however, /i/ behaves differently from /e/ and /o/. Whereas /o/ and /e/ mainly show tense realizations, most stressed /i/'s are realized as lax vowels. Unstressed /i/'s are even more often realized with a tense vowel than their stressed counterparts.

4 Discussion

4.1 General

The *Minimal Rhyme Constraint* predicts that Dutch syllables always end in a tense vowel or a VC-combination. Traditionally, phonological constraints are not provided with empirical evidence and/or numbers. This also holds for the *Minimal Rhyme Constraint*. The aim of this study was to investigate empirically the phonological intuition that Dutch cannot end in a lax vowel in a listening task. Interestingly, the three listeners labeled many vowels as lax. The amount of lax vowels varied according to several variables. The variables under study are discussed in the next sections.

4.2 Stress

The *Minimal Rhyme Constraint* was less frequently violated in stressed syllables than in unstressed ones. This finding can be related to the intuition of Kager (2003), who assumed the bimoraic restriction to be quite weak in unstressed syllables (e.g., the /a/ in *cadeau*, realized as [kɑ'do] 'present'). The effect of stress appears to be very robust. Although the Flemish and the Dutch stimuli generally

show different tendencies (see §4.4), stress appears to have a similar impact on both sides of the border: the interaction between *country* and *stress* was not statistically significant.

From the early days of Dutch phonology, it was clear that stressed and unstressed vowels behave differently (e.g., van Wijk 1932). Stress has also been crucial in phonological descriptions of vowel shortening. According to Kager (1989: 305), shortening is typical for "long vowels in initial syllables outside primary stress" and Booij (1995: 136) states that "[v]owels can be shortened in word-initial position under the condition that the syllable in which they occur does not bear the main stress of the word". When we see the large impact of stress on vowel pronunciation, it is somewhat surprising that this variable received so little attention in the phonological literature on the Dutch *Minimal Rhyme Constraint*, since, strictly speaking, every shortened tense vowel in an open syllable is a violation of the *Minimal Rhyme Constraint*. To our knowledge, however, this conclusion has never been drawn explicitly. There is only one refining, made by Kager (2003), who stated that the constraint may be very weak in unstressed syllables (see §1.3).

The relevance of the factor *stress* has been shown by empirical studies as well, for example in the syllabification experiments of Gillis and De Schutter (1996). Moreover, the duration measurements by Koopmans-van Beinum (1980) and van Bergem (1995) already showed that the durational difference between tense and lax vowels becomes very small in unstressed positions. Rietveld et al. (2004) demonstrated that vowels with primary stress have a longer duration than vowels with secondary stress, whereas vowels with secondary stress last longer than unstressed vowels. In other words, there is no doubt that stress influences vowel duration. Our results, too, illustrate that the factor stress should get (and keep) a central place in phonological theories on the *Minimal Rhyme Constraint*.

4.3 Relative position in the word

The *Minimal Rhyme Constraint* does not differentiate between the first and the final syllable in the word. However, lax vowels were encountered more frequently in the first than in the final syllable. This finding is entirely in line with the intuitions of, among others, Kager (1989) and Booij (1995), who associated vowel shortening with the first syllable. This result can also be related to measurements by Nooteboom (1972), who discovered that vowels in final syllables always have quite a long duration, even if they are not stressed (cf. "final lengthening"; see also Nooteboom 1997, Cambier-Langeveld 1997, 1999). Perhaps this contrast may

even be explained in terms of "prominence" (e.g., Laver 1995). Vowel reduction – including vowel shortening – can be interpreted as a loss of acoustic prominence. Dutch is a trochaic language, in which the final syllable often contains a schwa (e.g., *eten* ['etə] 'to eat', *boten* ['botə] 'boats' and *leerde* ['lerdə] 'learned'). From this point of view, we would expect bisyllabic words with two full vowels to show even more word-final lax vowels than we found now. After all, if the final syllable ends in a tense vowel, the contrast with schwa in, for example, ['etə] is maximal.

4.4 Country

Dutch is a pluricentric language whose spoken national varieties are not identical (e.g., Van de Velde 1996; van Heuven and Van de Velde 2010). The *Minimal Rhyme Constraint* does not differentiate between national varieties of Dutch. Our study, however, showed a significant difference between Flemish and the Dutch speakers. The Flemish informants produced fewer tense and more lax vowels than their Dutch counterparts did. This finding corresponds with the intuitions of Blancquaert (1936), Leenen (1965), Tops (2003) and a number of authors of Flemish pronunciation guides. Why the lax variant is used more often in Flanders than in the Netherlands is not clear.

What is striking, however, is that the same tendency has been observed in Surinamese Dutch (de Bies 2009). Surinamese Dutch would share its lax vowels in open syllables with the creole language Sranantongo, the lingua franca of Surinam. Belgian Dutch, for its part, shares its lax vowels with Belgian French (e.g., Remacle 1969; Warnant 1999). Inhabitants of the French-speaking provinces of Belgium were found to use lax vowels in syllables without primary stress where Frenchmen use tense vowels, as in *gén̲é̲ral* 'general', *ro̲sier* 'rose bush' and *dino̲saure* 'dinosaur'. These parallels between Dutch and a non-Germanic language remind of a phenomenon, known in historical linguistics as *Sprachbund*: non-related languages spoken in the same area can unexpectedly share some structural features (e.g., van Bree 1996: 269–270).

A better grip on the *country* factor requires more phonetic information on the quality and the duration of the vowels. Belgian and Netherlandic Dutch are not the first national varieties to show different paths in language evolution, including differences in vowel duration. For example, Morrison and Escudero (2007) showed that Peruvians produce somewhat longer Spanish vowels than speakers from Spain. Moreover, Escudero et al. (2009) discovered that vowels in Brazilian Portuguese generally have a longer duration than their European counterparts.

4.5 Vowel

The *Minimal Rhyme Constraint* does not make a distinction between individual vowels (e.g., /a/ vs. /i/). Nevertheless, Dutch phonologists noticed that syllable final /a/ is often realized as a lax vowel, especially in unstressed syllables (Kager 1989; Booij 1995). Our corpus contains a lot of lax /a/'s as well. However, whereas Kager (1989) and Booij (1995) seem to focus on non-final syllables, our dataset also contained examples of vowel shortening at the end of the word. This phenomenon appears to be stronger in Flanders than in the Netherlands. This finding can be linked to the (non-systematic) observations of Blancquaert (1936), Leenen (1965) and Tops (2003), who heard a lax instead of a tense realization of word-final /a/ in Flemish realizations of, for example, the word *villa*.

In the case of /o/ and /e/, a possible explanation for the larger amount of tense vowels – in comparison tot /a/ – could be that most Dutch speakers, in contrast to Flemish speakers, pronounce their /o/s and /e/'s as diphthongs ([o] > [o^{u}], [e] > [e^{i}]) (Van de Velde 1996). This pronunciation might prevent listeners from categorizing /o/ and /e/ as lax.

Some of our observations with respect to the individual vowels could also be a result of the unbalanced composition of the dataset. Maybe we only found a significant interaction between the position in the word and the vowel /i/ because word-final /a/ and /i/ are represented (much) better in the dataset than the other vowels (see Table 3). On the other hand, though, this representation could also be related to the sound system and the vowel distribution of Dutch. Perhaps (some) sounds simply prefer one position in the word to another. For example, word-final unstressed [e] is very unusual in Dutch. From our own experience, we know that it is only used in some proper nouns (e.g., *Antigone*) and in specialized vocabulary (e.g., *facsimile, apocope*). Moreover, not all syllable patterns are equally frequent in Dutch (e.g., De Schutter 1993; Daelemans et al. 1994). In other words, a thorough interpretation of the results presented in this paper – especially the findings with respect to the behavior of the individual vowels – would require a reliable and extensive description of the Dutch sound system. This description should preferably be based on spontaneously spoken Standard Dutch and indicate, among other things, the frequency of the respective stressed and unstressed vowels in specific positions in the word.

The exceptional behavior of /i/ (i.e., very little tense realizations in stressed syllables) could be related to the regional background of the listeners. All three grew up in the Brabantine dialect area. The perception of the listeners may be influenced by their Brabantine phonological system. Unlike Standard Dutch, Brabantine /i/'s have a long duration (e.g., Verhoeven and Van Bael 2002). Maybe the duration of the stressed /i/'s from the corpus was too short for the listeners to call them tense.

4.6 Rethinking the concept of the Minimal Rhyme Constraint: a few suggestions

Based on our results we think that the *Minimal Rhyme Constraint* should be thoroughly reconsidered. Our study is primarily empirical in nature and did not aim at reformulating the rules of Dutch phonological theory. However, we want to suggest two approaches that might be fruitful. The most drastic approach would be to rethink the very basic concept of the *Minimal Rhyme Constraint* for Dutch. It might be somewhat utopian to believe that every syllable of every individual should meet the requirements of one single universal or language-specific syllable template. A less radical approach would be to focus on the description of vowels in open syllables as "tense" or "lax". Maybe it is not always possible to differentiate between those two categories, both from a language production point of view as well as from a perceptual perspective. For some speakers the quality of vowels in open syllables might vary – depending on phonetic and phonological conditions – from tense-like to lax-like. On the other hand, the perception of the listeners might vary as well. The same vowel could be categorized as "tense" by one listener and as "lax" by another. This phenomenon is known as *categorical perception* (Harnad 1987). In this interpretation, not the *Minimal Rhyme Constraint* is questioned, but the match between the speech and the perceptual system of the listener.

At any rate, when the *Minimal Rhyme Constraint* shows serious cracks, several other basic statements of Dutch phonology should be reconsidered as well. For example, Dutch words like *appel* 'apple' and *engel* 'angel' are pronounced as [ɑpəl] and [ɛŋəl]. To make sure that the first syllable does not end in a lax vowel, the [p] of *appel* and the [ŋ] of *engel* are considered to be ambisyllabic (van der Hulst 1985; Booij 1995). This interpretation would not be necessary if syllables were permitted to end in a lax vowel. Moreover, some forms which are now described in the phonological literature as exceptions to the *Minimal Rhyme Constraint* would appear to be not that unusual, for example words with a lax vowel preceding /z/ (e.g., *puzzel*, *mazzel*) and French loan words like *cachet* and *bidet* with final [ɛ].

5 Conclusions

In this paper, we have studied vowel pronunciation in open syllables of bisyllabic Dutch words with two full vowels. The high proportion of lax vowels found in (unstressed) open syllables suggests that the *Minimal Rhyme Constraint* needs to be refined. The factor causing the largest differences was *stress*. Based on

previous phonological and phonetic studies, we expected unstressed syllables to contain relatively more lax vowels than stressed syllables do. We also found a striking difference between the Flemish and the Dutch stimuli, especially with respect to the unstressed syllables: the Flemish informants produced fewer tense and more lax vowels than their Dutch counterparts did. No main effect was found for age or gender.

With respect to the *relative position in the word*, generally speaking, the first syllable ended in a lax vowel more often than the second syllable did. In other words, the second syllable contained more tense vowels, both in Flanders and in the Netherlands. The vowel with the highest proportion of lax variants is /a/.

By way of conclusion, let us put forward some suggestions for further research. First, it would be interesting to look at our research question from a perceptual perspective as well. Most phonological intuitions about Dutch syllable structure are formulated by Dutch linguists, whereas the categorization task in the present study was carried out by three Flemish linguists. Several studies have shown that vowel categorization can be influenced by the mother tongue of the listeners. The same phonetic cue, e.g., vowel duration, can be implemented differently according to someone's mother tongue (e.g., Ylinen et al. 2005; van der Feest and Swingley 2011). An exploratory study showed a similar tendency for Flemish and Dutch listeners as well: vowels categorized as lax by the Flemish listeners were often regarded as tense by their Dutch counterparts (Kloots et al. 2006; Kloots et al. 2010). In future studies, this factor should certainly be explored in more detail.

A non-variable factor in this study was the number of syllables. Phonological descriptions always focus on words with two or more syllables. As the focus was on bisyllabic words, syllables with secondary stress (e.g., *Panama*̲ ['panama]) were also beyond the scope of this study. Future research could try to shed light on potential differences between vowels with primary stress, secondary stress or no stress at all. Rietveld et al. (2004), for example, have already demonstrated that vowels in syllables with primary stress have a longer duration than secondary stressed vowels and that vowels with secondary stress have a longer duration than their unstressed counterparts.

Finally, more attention could be paid to the distributional features of the individual vowels. If both the factors *vowel* (/a/-/e/-/i/-/o/) and *position in the word* are varied, we cannot rule out the possibility that certain vowels are by definition more frequent in certain positions than in others, not because the researcher has made use of an unbalanced dataset, but simply because they are. At present, it is difficult to formulate hypotheses and predictions based on this factor, because more information is needed on the prevalence of individual vowels in specific – stressed and unstressed – positions in spoken Standard Dutch.

Acknowledgments: We are grateful to Marc Swerts (Tilburg University) for his invaluable assistance in the listening task.

References

Adank, Patti, Roeland van Hout & Roel Smits. 2004. An acoustic description of the vowels of Northern and Southern Standard Dutch. *Journal of the Acoustical Society of America* 116. 1729–1738.

van Bergem, Dick. 1995. *Acoustic and lexical vowel reduction*. Amsterdam: Universiteit van Amsterdam dissertation.

de Bies, Renata. 2009. *Woordenboek Surinaams Nederlands* [Dictionary of Surinamese Dutch]. Houten: Het Spectrum.

Blancquaert, Edgard. 1936. Noord- en Zuidnederlandsche schakeeringen in de beschaafd-Nederlandsche uitspraak [Northern and southern shades in the received pronunciation of Dutch]. *Verslagen en Mededeelingen van de Koninklijke Vlaamsche Academie voor Taal- en Letterkunde* 1936. 597–612.

Blancquaert, Edgard. 1957. *Praktische uitspraakleer van de Nederlandse taal* [Practical pronunciation manual of the Dutch language], 5th edn. Antwerp: De Sikkel.

Booij, Geert. 1995. *The phonology of Dutch*. Oxford: Clarendon Press.

de Bot, Kees. 1985. Onderzoek naar taalverandering en het gebruik van de 'apparenttime' methode [Study of language change and the use of the apparent time method]. *Forum der Letteren* 26. 33–40.

Botma, Bert, Koen Sebregts & Dick Smakman. 2012. The phonetics and phonology of Dutch mid vowels before /l/. *Laboratory Phonology* 3. 273–297.

van Bree, Cor. 1996. *Historische taalkunde* [Historical linguistics]. Leuven & Amersfoort: Acco.

Cambier-Langeveld, Tina. 1997. The domain of final lengthening in the production of Dutch. In Jane Coerts & Helen de Hoop (eds.), *Linguistics in the Netherlands 1997*, 13–24. Amsterdam & Philadelphia: John Benjamins.

Cambier-Langeveld, Tina. 1999. The interaction between final lengthening and accentual lengthening: Dutch versus English. In Renée van Bezooijen & René Kager (eds.), *Linguistics in the Netherlands 1999*, 13–25. Amsterdam & Philadelphia: John Benjamins.

Christensen, Rune. 2011. *A tutorial on fitting cumulative link mixed models with clmm2 from the ordinal Package*. http://cran.r-project.org/web/packages/ordinal/vignettes/clmm2_tutorial.pdf (accessed 26 November 2013)

Clyne, Michael. (ed.). 1992. *Pluricentric Languages: Differing norms in different nations*. Berlin & New York: Mouton de Gruyter.

Cohen, Antonie, Carl Ebeling, Pier Eringa, Klaas Fokkema & André van Holk. 1959. *Fonologie van het Nederlands en het Fries: Inleiding tot de moderne klankleer* [The phonology of Dutch and Frisian: Introduction to modern phonetics]. The Hague: Martinus Nijhoff.

Collins, Beverley & Inger Mees. 1999. *The phonetics of English and Dutch,* 4th rev. edn. Leiden: Brill.

Daelemans, Walter, Steven Gillis & Gert Durieux. 1994. The acquisition of stress: A data-oriented approach. *Computational Linguistics* 20. 421–451.

De Schutter, Georges. 1993. Klemtoonpatronen in de Nederlandse woordenschat [Stress patterns in Dutch vocabulary]. *Leuvense Bijdragen* 82. 61–82.

De Schutter, Georges. 1994. Dutch. In Ekkehard König & Johan van der Auwera (eds.), *The Germanic languages*, 439–477. London & New York: Routledge.
De Schutter, Georges & René Collier. 1986. Intuïtieve syllabisering in het Nederlands [Intuitive syllabification in Dutch]. *De Nieuwe Taalgids* 79. 441–452.
Ernestus, Mirjam & Natasha Warner. 2011. An introduction to reduced pronunciation variants. *Journal of Phonetics* 39. 253–260.
Escudero, Paola, Paul Boersma, Andreia Schurt Rauber & Ricardo Bion. 2009. A cross-dialect acoustic description of vowels: Brazilian and European Portuguese. *Journal of the Acoustical Society of America* 126. 1379–1393.
van Eerten, Laura. 2007. Over het Corpus Gesproken Nederlands [On the Spoken Dutch Corpus]. *Nederlandse Taalkunde* 12. 194–215.
van der Feest, Suzanne & Daniel Swingley. 2011. Dutch and English listeners' interpretation of vowel duration. *Journal of the Acoustical Society of America* 129 (3). 57–63.
Gillis, Steven & Georges De Schutter. 1996. Intuitive syllabification: universals and language specific constraints. *Journal of Child Language* 23. 487–514.
van Ginneken, Jacques. 1941. Gedekte en ongedekte klinkers [Lax and tense vowels]. *Onze Taaltuin* 10. 97–102.
Grondelaers, Stefan & Roeland van Hout. 2010. Is Standard Dutch with a regional accent standard or not? Evidence from native speakers' attitudes. *Language Variation and Change* 22. 221–239.
Grondelaers, Stefan & Roeland van Hout. 2011. The standard language situation in the Low Countries: Top-down and bottom-up variations on a diaglossic theme. *Journal of Germanic Linguistics* 23. 199–243.
Gussenhoven, Carlos. 1999. Dutch. In *Handbook of the International Phonetic Association: A guide to the use of the International Phonetic Alphabet,* 74–77. Cambridge: Cambridge University Press.
Harnad, Stevan (ed.). 1987. *Categorical perception: The groundwork of cognition*. Cambridge: Cambridge University Press.
van Heuven, Vincent & Hans Van de Velde. 2010. De uitspraak van het hedendaags Nederlands in de Lage Landen [The pronunciation of contemporary Dutch in the Low Countries]. In Jane Fenoulhet & Jan Renkema (eds.), *Internationale neerlandistiek: een vak in beweging* (*Lage Landen Studies* 1), 183–209. Ghent: Academia Press.
van Heuven, Vincent, Els J. van Houten & Jan de Vries. 1986. De perceptie van Nederlandse klinkers door Turken [The perception of Dutch vowels by Turks]. *Spektator* 15. 225–238.
van Hout, Roeland, Georges De Schutter, Erika De Crom, Wendy Huinck, Hanne Kloots & Hans Van de Velde. 1999. De uitspraak van het Standaard-Nederlands: Variatie en varianten in Vlaanderen en Nederland [The pronunciation of Standard Dutch: Variation and variants in Flanders and the Netherlands]. In Erica Huls & Bert Weltens (eds.), *Artikelen van de Derde Sociolinguïstische Conferentie,* 183–196. Delft: Eburon.
van der Hulst, Harry. 1985. Ambisyllabicity in Dutch. In Hans Bennis & Frits Beukema (eds.), *Linguistics in the Netherlands 1985,* 57–66. Dordrecht & Cinnaminson, NJ: Foris.
Kager, René. 1989. *A metrical theory of stress and destressing in English and Dutch*. Utrecht: Utrecht University dissertation.
Kager, René. 2003. Intuïtieve syllabificatie bij kinderen: een optimaliteitsmodel [Intuitive syllabification in children: an optimality model]. In Georges De Schutter & Steven Gillis (eds.), *Fonologische kruispunten*, 135–163. Ghent: Koninklijke Academie voor Nederlandse Taal- en Letterkunde.

Kleine, Ane. 2003. Standard Yiddish. *Journal of the International Phonetic Association* 33. 261–265.

Kloots, Hanne. 2008. *Vocaalreductie in het Standaardnederlands in Vlaanderen en Nederland* [Vowel reduction in Standard Dutch in Flanders and the Netherlands]. Delft: Eburon.

Kloots, Hanne, Evie Coussé & Steven Gillis. 2006. Vowel labelling in a pluricentric language: Flemish and Dutch labellers at work. In Jeroen van de Weijer & Bettelou Los (eds.), *Linguistics in the Netherlands 2006,* 126–136. Amsterdam & Philadelphia: John Benjamins.

Kloots, Hanne & Steven Gillis. 2011. Gespannen en ongespannen klinkers aan het syllabe-einde: Een overzicht van 25 jaar Antwerps onderzoek op het terrein [Syllable-final tense and lax vowels: An overview of 25 years of Antwerp research]. *Verslagen en Mededelingen van de Koninklijke Academie voor Nederlandse Taal- en Letterkunde* 121(2). 129–154.

Kloots, Hanne, Jo Verhoeven, Evie Coussé & Steven Gillis. 2010. The role of duration in vowel categorization. Flemish vs. Dutch listeners: a case study. *Studies van de BKL*, vol. 5 http://webh01.ua.ac.be/linguist/SBKL/sbkl2010/klo2010.pdf (accessed 26 November 2013)

Kooij, Jan & Marc van Oostendorp. 2003. *Fonologie. Uitnodiging tot de klankleer van het Nederlands* [Phonology. An invitation to the sound system of Dutch]. Amsterdam: Amsterdam University Press.

Koopmans-van Beinum, Florien. 1980. *Vowel Contrast Reduction. An Acoustic and Perceptual Study of Dutch Vowels in Various Speech Conditions*. Amsterdam: Universiteit van Amsterdam dissertation.

Laan, Gitta. 1997. The contribution of intonation, segmental durations, and spectral features to the perception of a spontaneous and a read speaking style. *Speech Communication* 22. 43–65.

Ladefoged, Peter. 2006. *A course in phonetics,* 5th edn. Boston: Thomson Wadsworth.

Lass, Roger. 1976. *English phonology and phonological theory: Synchronic and diachronic studies*. Cambridge: Cambridge University Press.

Leenen, Jozef. 1965. Vreemde woorden op zijn Nederlands uitgesproken [Foreign words with a Dutch pronunciation]. *Nu Nog* 13. 1–4.

Lodge, Ken. 2009. *A critical introduction to phonetics*. London & New York: Continuum International Publishing Group.

Luyckx, Kim, Hanne Kloots, Evie Coussé & Steven Gillis. 2007. Klankfrequenties in het Nederlands [Sound frequencies in Dutch]. In Dominiek Sandra, Rita Rymenans, Pol Cuvelier & Peter Van Petegem (eds.), *Tussen taal, spelling en onderwijs: Essays bij het emeritaat van Frans Daems,* 141–154. Ghent: Academia Press.

Morrison, Geoffrey & Paola Escudero. 2007. A cross-dialect comparison of Peninsular- and Peruvian-Spanish vowels. In Jürgen Trouvain & William Barry (eds.), *Proceedings of the 16th International Congress of Phonetic Sciences*, Saarbrücken, 6–10 of August 2007, 1505–1508. Dudweiler: Pirrot.

Moulton, William. 1962. The vowels of Dutch: phonetic and distributional classes. In *Studia Gratulatoria dedicated to Albert Willem de Groot,* 294–312 (= *Lingua* 11). Amsterdam: North-Holland.

Mussche, Achilles. 1962. *Handleiding voor de praktijk van het Algemeen Beschaafd: Voor middelbaar en normaalonderwijs* [Manual for the practice of received pronunciation: For secondary education and teacher training], 16th edn. Brussels: A. De Boeck.

Nooteboom, Sieb. 1972. *Production and perception of vowel duration: A study of durational properties of vowels in Dutch*. Utrecht: Utrecht University dissertation.

Nooteboom, Sieb. 1997. The prosody of speech: Melody and rhythm. In William Hardcastle & John Laver (eds.), *The handbook of phonetic sciences,* 640–673. Oxford: Blackwell.

van Oostendorp, Marc. 2000. *Phonological projection: A theory of feature content and prosodic structure*. Berlin & New York: Mouton de Gruyter.

Remacle, Louis. 1969. *Orthophonie française: Conseils aux Wallons*, 2nd edn. Liège: Les Lettres Belges.

Rietveld, Tony, Joop Kerkhoff & Carlos Gussenhoven. 2004. Word prosodic structure and vowel duration in Dutch. *Journal of Phonetics* 32. 349–371.

Rischel, Jørgen. 1992. Formal linguistics and real speech. *Speech Communication* 11. 379–392.

Schiller, Niels, Antje Meyer & Willem Levelt. 1997. The syllabic structure of spoken words: Evidence from the syllabification of intervocalic consonants. *Language and Speech* 40. 103–140.

Strik, Helmer. 2001. "Dat heb ik helemaal niet gezegd!" De prestaties van de spraakherkenner ['I did not say that!' The performances of the speech recognizer]. *Onze Taal* 70. 284–286.

Timmermans, Bernadette. 2008. *Klink klaar: Uitspraak- en intonatiegids voor het Nederlands* [Sound clear: Pronunciation and intonation guide for Dutch], rev. edn. Leuven: Davidsfonds.

Tops, Guy. 2003. De "Franse" uitspraak van sommige leenwoorden in Vlaams Nederlands [The "French" pronunciation of certain loan words in Flemish Dutch]. In Alex Vanneste, Peter De Wilde, Saskia Kindt & Joeri Vlemings (eds.), *Memoire en temps advenir: Hommage à Theo Venckeleer* (Orbis Supplementa 22), 453–466. Leuven: Peeters.

Van de Velde, Hans. 1996. *Variatie en verandering in het gesproken Standaard-Nederlands (1935–1993)* [Variation and change in spoken Standard Dutch (1935–1993)]. Nijmegen: Katholieke Universiteit Nijmegen dissertation.

Van de Velde, Hans & Muriel Houtermans. 1999. Vlamingen en Nederlanders over de uitspraak van nieuwslezers [Flemings and Dutchmen on the pronunciation of newsreaders]. In Erika Huls & Bert Weltens (eds.), *Artikelen van de Derde Sociolinguïstische Conferentie,* 451–462. Delft: Eburon.

Van Maele, Geert. 1972. *Handleiding bij de uitspraakleer* [Phonetics Manual]. Lier: Van In.

Verhoeven, Jo & Christophe Van Bael. 2002. Akoestische kenmerken van de Nederlandse klinkers in drie Vlaamse regio's [Acoustic features of Dutch vowels in three Flemish regions]. *Taal en Tongval* 54. 1–23.

Warnant, Léon. 1999. Phonétique et phonologie. In Daniel Blampain, André Goose, Jean-Marie Klinkenberg & Marc Wilmet (eds.), *Le français en Belgique: Une langue, une communauté,* 163–174. Brussels: Duculot.

van Wijk, Nicolaas. 1932. De moderne phonologie en de omlijning der taalkategorieën [Modern phonology and the definition of linguistic categories]. *De nieuwe taalgids* 26. 65–75.

van Wijk, Nicolaas. 1941. Scherp en zwak gesneden klinkers [Lax and tense vowels]. *De nieuwe taalgids* 35. 15–24.

Ylinen, Sari, Anna Shestakova, Paavo Alku & Minna Huotilainen. 2005. The perception of phonological quantity based on durational cues by native speakers, second-language users and nonspeakers of Finnish. *Language and Speech* 48. 313–338.