Towards a New Representation of the Dutch Syllable

An Experimental Study to Degemination and Ambisyllabicity

Master Thesis

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Towards a new representation of the Dutch syllable: an experimental study to degemination and ambisyllabicity

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Abstract:

Dutch intervocalic consonants that are preceded by a lax vowel are considered to be ambisyllabic, that is, they are assumed to belong to both the preceding and the following syllable at the same time (Van der Hulst, 1985). Ambisyllabicity followed from the idea that tense vowels are underlyingly long and lax vowels underlyingly short, and that a syllable rhyme must be binary. Since the underlying representation of ambisyllabic (short) and geminate (long) consonants is identical, languages should either have ambisyllabicity or have a length distinction between short and long consonants. Previous studies showed that the core assumption of ambisyllabicity is wrong – all vowels are underlyingly short and are lengthened only because of stress – without properly investigating what that could imply for ambisyllabicity.

In this thesis, we explore the validity of ambisyllabicity based on production and perception experiments we carried out throughout the Netherlands. The experiments show that long consonants (that should be degeminated, and thus should have a similar representation as single consonants) remain up to 34 milliseconds longer than their regular single counterparts, while ambisyllabic and regular single intervocalic consonants, that are assumed to have a different underlying structure, show no duration differences. Our experiments thus show that it is more likely that Dutch has an opposition between short and long consonants rather than that is has ambisyllabicity. We therefore propose to abandon the idea of ambisyllabicity and to represent intervocalic consonants just as single onset consonants.

Contents

Chapter 1. Introduction

In 1985, Van der Hulst introduced the concept of ambisyllabicity for Dutch: an intervocalic consonant following a lax vowel should belong to both the preceding and the following syllable. The most important reason for doing so is the way stress is assigned in Dutch: by placing these intervocalic consonants within the previous syllable, this syllable receives enough weight to count as heavy, hence attracting main stress to it. The stress analysis of Van der Hulst (1985) was based on tense vowels that are underlyingly long, but in Gussenhoven (2009) it is argued that all vowels should be underlyingly short. Gussenhoven still incorporated ambisyllabicity in his analysis, but as he seems to falsify the assumptions for ambisyllabicity, why is ambisyllabicity itself still part of the analysis? Is it not possible to account for Dutch stress — which was one of the main reasons for assuming ambisyllabicity — without spreading this consonant over two syllables?

One interesting property of ambisyllabicity is that it shares the same underlying representation as geminates, although the durations of ambisyllabic and geminate consonants differ completely (Jongman, 1998; Van der Hulst, 1984). A language can thus either have ambisyllabicity or gemination: the same structural opposition cannot have two different realizations. In this thesis, we will investigate the possibility of abolishing ambisyllabicity by introducing gemination for Dutch. To test whether gemination occurs, we will use data from production and perception experiments. These experiments are held in four different regions through the Netherlands, allowing us to distinguish between true effects of gemination and possible regional pronunciation variants. We will discuss the results of our experiments in order to make a judgment on the necessity of the concept of ambisyllabicity.

The structure of this thesis is as follows. In the next chapter, Chapter 2, we will provide the reader with an overview of the current literature on ambisyllabicity. As the main argument in favor of it is word stress, we will also present the current state of affairs in Dutch (main) stress.

The second part of that chapter is dedicated to previous studies investigating consonant duration in. Then, in Chapter 3, we will describe the proceedings of our production experiment, and report on their results. Next, in Chapter 4, we will do the same for our perception experiment. Then, in Chapter 5, we will discuss how the results should be interpreted in the light of gemination and ambisyllabicity. We will show that an explanation that still preserves ambisyllabicity is not desirable, and that excluding ambisyllabicity from the theory leads to more transparency. Finally, we will draw our conclusions in Chapter 6.

Chapter 2. Theoretical Background

In this thesis, we perform production and perception experiments to test whether ambisyllabicity is still of use in Dutch phonology. Before we introduce the experiments, we will use this chapter to investigate why ambisyllabicity was even assumed at all. Hence, the first section of this chapter will focus on ambisyllabicity and its role in the literature on Dutch syllable structure and main stress. Both arguments in favor of and against ambisyllabicity will be discussed. As announced in the introduction chapter, ambisyllabic consonants share the same moraic representation as geminate consonants. The second part of this chapter will therefore concentrate on geminates and – as is assumed to be the case for Dutch – degemination. The third part of this chapter is dedicated to previous studies that resemble our experiments; we will discuss these studies to further motivate our own study to this topic.

2.1 Ambisyllabicity and Dutch Stress

Ambisyllabicity finds is origins in the dissertation of Kahn (1976), defending the notion of the syllable. This notion of the syllable already emerged out of criticism by Kiparsky (1973) and Liberman and Prince (1977) against the way the *Sound Pattern of English* of Chomsky and Halle (1968) dealt with English word stress.

In *SPE*, phonological theories were based on segmental properties (distinctive features). The only greater unit that surpassed the phoneme was the word, indicated by word boundary segments. Although many phonetic observations could be explained by Chomsky and Halle's linear phonology, some aspects of their proposals were considered to be problematic. One of these aspects was their analysis of English word stress, for which they proposed a complicated rule, including the use of segmental clusters of (tense) vowels and possibly one or more consonants and the application of parenthesis in disjunctive order. This rule, given in (1), exemplifies

(1) ENGLISH MAIN STRESS: $V \rightarrow [1\text{stress}] \,/\, \_\, C_0\, ((\, [^{-\text{tense}}_{\ \ \text{V}}]\, C_0^1)\, [^{-\text{tense}}_{\ \ \text{V}}]\, C_0)$

the many criticisms against a segmental-based approach for English main stress.

The working of (1) is as followed: main stress is always attributed to the vowel of one of the three rightmost clusters of the word. There are strong and weak clusters: a weak cluster is a [–tense] vowel followed by maximally one consonant, and a strong cluster is either a [+tense] vowel (possibly followed by any number of consonants) or any vowel followed by two or more consonants. In the last cluster of the word, the number of final consonants is not restricted. If there is a strong cluster among the last three of the word, the rightmost strong cluster receives main stress. If there is no strong cluster among these three, the first vowel of these three clusters receives main stress.

The criticism of Liberman and Prince (1977) is based on the fact that this rule does not refer to any natural class at all. Most rules in *SPE* refer to natural classes defined by distinctive features that are justified by other rules as well. Besides stress, there is no other phenomenon that only occurs on the rightmost strong cluster of a word. Furthermore, there seems to be no logic in allowing (1) to be a valid rule, but not a rule assigning main stress to the first strong cluster among the *five* rightmost clusters. In that sense, (1) predicts correctly which vowel should be stressed, but it does not explain anything at all.

Another problematic aspect of (1) is the fact that it uses parentheses that should be used in disjunctive order, that is, a rule should first be executed with the largest possible context, including all context that is placed both inside and outside parenthesis, and only if this context is not applicable it should ignore context outside the parentheses. This type of rule ordering is suggested to be a universal property of phonological rules (Chomsky & Halle, 1968, p.77), but Kiparsky (1973) shows an opposite case in the Karok language, where a postalveolarization rule starts with the smallest possible context and only if that context is not applicable, it starts including context outside of the parentheses.

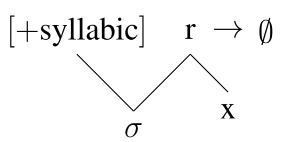
Kiparsky (1973) and Liberman and Prince (1977) thus show that there are fundamental problems with the segmental phonology in *The Sound Pattern of English* of Chomsky and Halle (1968) and therefore propose a non-segmental approach to main stress. This approach makes uses of the syllable, an intermediate level between the segment and the vowel, and is assigned properties that *SPE* attributed to the vowels, such as stress and intonation (Hermans, 2012). But not only the use of distinctive features in a rule should be justified by the use of these features in other rules, also the use of the syllable should be justified by other cases than stress. It is in this light that the dissertation of Kahn (1976) should be seen: Kahn, a student of Kiparsky, shows that many phenomena in English can be explained in a more elegant way by referring to the syllable.

The core chapter of Kahn (1976) provides eight examples of phonological phenomena that could be explained in a more elegant way by using the notion of the syllable. In many languages, we encounter phonological rules that use the context ___$\{{C \atop \#}\}$ (i.e. post-vocalic contexts before another consonant or word boundary). The disjunction of $\{{C \atop \#}\}$ is considered highly problematic, as the "the class of consonants (...) and word-boundary (...) do not form a natural class – in fact they have in common no feature at all" (Kahn, 1976, p.23). Instead, it would be better to refer to *syllable-final*.

In some dialects of Dutch, there is an alternation between [ʋ] and [β], for instance between *water*[ʋatər] 'water' and *leeuw* [leβ] 'lion'. In linear phonology, it is said that [ʋ] becomes [β] in the context ___$\{{C \atop \#}\}$. However, this would mean that this rule should also be applied in *leeuwin* /leʋ+ɪn/ 'lion.FEM', while this is not the case: *leeuwin* is pronounced [le.βɪn], not [le.ʋɪn].

The notion of the syllable is used as well to explain emphasis spreading in Cairene Arabic. If a consonant is emphasized, this emphasis is spread to the following vowel and tautosyllabic consonants. For instance, /ḷaṭif/ 'pleasant.MASC' becomes [ḷạ.ṭịf̣], while /ḷaṭif-a/ 'pleasant.FEM' becomes [ḷạ.ṭị.fa] (Hargus, 2016). In a linear phonology without using syllables, the spreading of emphasis would be explained as *'spread emphasis to the following vowel, and spread it to the consonant following this vowel if this consonant is followed by a word-boundary or another consonant.'* With a reference to segments that occur within the same syllable, the arbitrary $\{{C \atop \#}\}$ disjunction is not needed anymore.

The examples given by Kahn (1976) concern cases similar to the examples above. For instance, the loss of /r/ in some dialects of English is under *SPE* considered to take place in

(2)


the context $\_\_\_\left\{\begin{smallmatrix}C\\ \#\end{smallmatrix}\right\}$. However, Kahn assumes a specific organization of the segments within the syllables in order to justify the syllable. In the case of the loss of /r/, rule (2) is proposed (Kahn, 1976, p.109, (42)). This rule deletes the /r/ if it follows a vowel that is located within the same syllable, but not if this /r/ is also the first segment of the following syllable. Similar examples given by Kahn include the raising of /æ/ when followed by a non-syllable-initial nasal consonant and the deletion of a non-syllable-initial /g/ when following /ŋ/.

Kahn (1976) thus assumes that non-syllable-initial is not necessary the same as syllable-final: Kahn argues that some consonants can (and should) by both syllable-final and syllable-initial at the same time. In that case, they are called ambisyllabic.

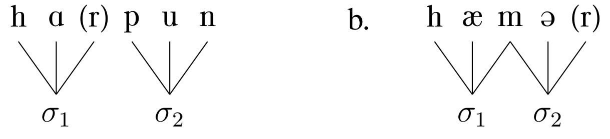
2.1.1 What is ambisyllabicity?

As stated in the introduction, ambisyllabicity is the fact that a segment belongs to two syllables. When dividing a word into syllables, one starts with the vowels of these syllables (i.e. the nuclei) and then assigns the consonants to one of the syllables. For many words, this division is quite simple, and based on the sonority scale of a language, requiring a syllable onset to be ordered from low to high sonority and the syllable coda to be ordered from high to low sonority (Burquest & Payne, 1993). Lowly sonorous segments include plosives and fricatives, highly sonorous segments include vowels and glides. In this light, a word like *April* will not be syllabified as [eɪpr.əl] , because /p/ is – at least for English – less sonorous than /r/. For the same reasons, *harpoon* /hɑrpuːn/ will be syllabified as [hɑr.puːn], and not as *[hɑ.rpuːn].

For words as *harpoon*, the syllabification is relatively simple, but this is not always the case: Kahn gives as example the word *hammer*, for which he argues that "it would seem completely arbitrary to insist that *hammer* contains a syllable boundary either before or after the [m]" (Kahn, 1976, p.33). He claims that to all phonologists it is clear that *hammer* contains two syllables, but that the discussion on where to place this boundary is not necessary. The formal representation of the words *harpoon* and *hammer* is given in (3).

For Dutch, ambisyllabicity has been claimed for intervocalic consonants after short vow-

(3) a. b.



els by Van der Hulst (1984, 1985). Reasons to incorporate ambisyllabicity for these vowels include vowel properties, distributional observations and stress assignment. When it comes to Dutch vowels, phonologists distinguish mainly two vowel classes: on the one hand, the short or lax vowels (cf. class 1 in Table 2.1) and on the other hand the long or tense vowels (cf. class 2 in Table 2.1) (Booij, 1995; Collins & Mees, 1999; Gussenhoven, 1992; Trommelen & Zonneveld, 1989; Van der Hulst, 1985). Their different behavior is captured by Van der Hulst (1984) as follows: within a syllable, a class 2 vowel is underlyingly long and can be followed by maximally one consonant, and may be the last segment of a word, while a class 1 vowel is underlyingly short and can be followed by up to two consonants within the same syllable, but is not allowed to occur word-finally or in an open syllable. As long vowels are considered to occupy two positions (and short vowels and consonants only one), Van der Hulst suggest that a syllable should in general consist of at least two and maximally three rhyme positions: either a long vowel followed by maximally one coda consonant, or a short vowel followed by at least one and maximally two consonants. This rhyme requirement is confirmed by Van der Hulst's observation that words such as [kre.ol] 'creole' or [hi.at] 'hiatus' (words in which the first syllable ends in a tense vowel) are existing words, while words with a first syllable ending in a lax vowel are not attested (e.g. *[krE.ol] or *[hI.at], although some counterexamples will be given in Chapter 5).

This requirement makes that *kapen* 'to hijack' can be syllabified as [kaː.pə], but *kappen* 'to chop' cannot be syllabified as [kɑ.pə], because the first rhyme would contain only one element (a short vowel). Therefore, the /p/ in *kappen* should at least be the coda consonant of the first syllable. On the other hand, the /p/ in *kappen* should also be the onset of the last syllable in order to obey the MAXIMAL ONSET PRINCIPLE (Selkirk, 1981). This principle requires

Class		Vowels
1.	Lax / Short / Checked	ɪ, ʏ, ɛ, ɔ, ɑ
2.	Tense / Long / Free	i, y, u, eː øː, oː, aː
3.	Marginally occurring	iː, yː, uː, ɛː, œː, ɔː
4.	Diphthongs	ɛi, œy, ʌu
5.	Schwa	ə

Table 2.1: Dutch vowels

the onset of a syllable to be as large as possible – as long as this is allowed according to the phonotactics the language. If the /s/ would not be the onset of the following syllable as well, this principle would by violated.

Besides, for words with voiced intervocalic consonants that follow a lax vowel, such as /hɛbə/ 'to have', a syllabification with only a coda (as in [hɛb.ə]) would lead to the following problem: in Dutch, all syllable-final consonants are subject to a devoicing rule, which would turn [hɛb.ə] into [hɛp.ə] if the /b/ was only syllable-final. By using ambisyllabicity, the /b/ is both coda (taking a second position in the rhyme of the first syllable) and onset (satisfying the MAXIMAL ONSET PRINCIPLE and preventing devoicing).

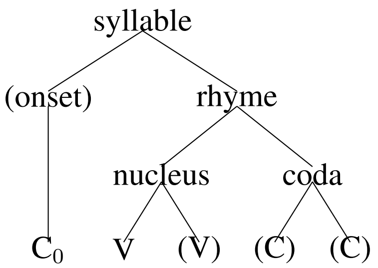
Next to distributional observations and the consequent syllable structure, the assignment of word stress forms an important argument in favor of ambisyllabicity. Before discussing the role of ambisyllabicity on word stress, we will first show how regular word stress is attributed in Dutch in the following subsection.

2.1.2 Dutch Stress

There is an extensive literature on Dutch main stress, all leading to the conclusion that main stress in Dutch is on one of the last three syllables of the word, depending on the weight of these syllables. How this weight is defined depends on the theoretical framework that one adopts. Van der Hulst's (1984) proposal of ambisyllabicity is based on a metrical theory using word- and syllable trees and the assumption that all lax vowels (cf. class 1 in Table 2.1) are underlyingly short and all tense vowels (cf. class 2 in Table 2.1 are underlyingly long. This last assumption has been falsified by Van Oostendorp (1995) by using [±lax] instead of [±long] to distinguish vowels. Within the framework of Optimality Theory (OT), the tense–lax distinction has been employed to demonstrate Dutch main stress by Gussenhoven (2009), although he still uses ambisyllabicity. Therefore, we will not only demonstrate how ambisyllabicity is employed within the framework of metrical word- and syllables trees (with a long–short distinction), but also how it is incorporated within an OT solution (with a tense–lax distinction) to Dutch stress.

2.1.2.1 Dutch Stress Using Word- and Syllable Trees

As stated above, main stress is almost always on one of the last three syllables on the word, depending on the weight of the syllable. The weight of a syllable is determined by the branchingness of its rhyme. In (4), we find the syllable tree that helps to determine the weight, based on Van der Hulst (1984), Visch and Kager (1984) and Trommelen and Zonneveld (1989).

(4)


As only the rhyme contributes to a syllable's weight, we will for now ignore the onset, which can by empty or contain any number of consonants. Recall from section 2.1.1 that a rhyme is assumed to contain at least two positions. The first of these positions is the vocalic nucleus, the second can be either vocalic (resulting in a long, tense vowel) or consonantal (resulting in a short, lax vowel followed by a coda). Both VV and VC rhymes may be followed by another consonant. Word-finally, up to two other consonants may follow after this, but then these consonants are considered to be appendices to the syllable, instead of being part of the syllable itself (e.g. in *herfst* [hɛrfst] 'autumn', the [s] and [t] are appendices) (Trommelen & Zonneveld, 1989). Although both VV and VC rhymes contain both two positions, only VC rhymes are heavy; VV rhymes are light. The difference between VV- and VC-rhymes is the level on which there is a branching: we see in (4) that VC rhymes must have a branching rhyme, but VV not; they have a branching nucleus instead. Only branching rhymes (i.e. a rhyme with both a nucleus and a coda) lead to heaviness, so syllables without a coda cannot be heavy. Rhymes with three positions (either VVC or VCC) are considered to be superheavy.

The first step in determining word stress is the creation of feet. In Dutch, feet are quantity-sensitive trochees, which means that in general there is a rhythm of two syllables grouped

(5) a.

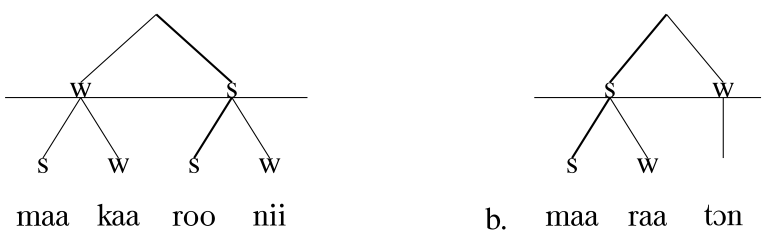

together, of which the first syllable is considered to be strong and the second to be weak. The only restriction to this is the weight of the syllable: a heavy syllable cannot be placed in the weak position of the foot. This is why the feet in a word like (5a) *macaroni* ‘macaroni’, which has four open syllables, contain two syllables each, but the final foot in (5b) *marathon* ‘marathon’, which has two open followed by one closed syllable, can only contain one syllable. If we were to create a foot with the syllables /raa/ and /tɔn/, the closed (thus heavy) syllable would be in the weak position of the foot, which is not allowed.

The next step in the construction of the word trees is the hierarchical ordering of the feet. Van der Hulst (1984) makes use of LCPR (Lexical Category Prominence Rule) to do so, other proposals (e.g. so-called *end rules* of Trommelen and Zonneveld (1989)) are very similar to this. The main idea of LCPR and similar proposals is that the feet are placed in a tree of which each branching is binary, starting from right to left. Both examples in (5) have two feet, an example containing three feet is given later on, for instance in (9c). If a node in the word tree branches, LCPR indicates which of the two constituents should be labeled strong and which one weak. The labeling rules of LCPR are given in (6), taken from (102) in Van der Hulst (1984, p.240).

(6) LCPR: In the configuration [AB], B is strong iff
- it branches,
- it dominates a superheavy syllable, or
- it dominates a [+F] marked syllable.

For the words in (5), this leads to the word trees in (7). The horizontal lines separates the internal ordering of the feet from their hierarchy within the word. In both words, the two feet are constituents of the same node. In (7a), the right constituent branches into the syllables /roo/ and /nii/, therefore this constituent is strong. In (7b), the right constituent does not branch,

(7) a. b.

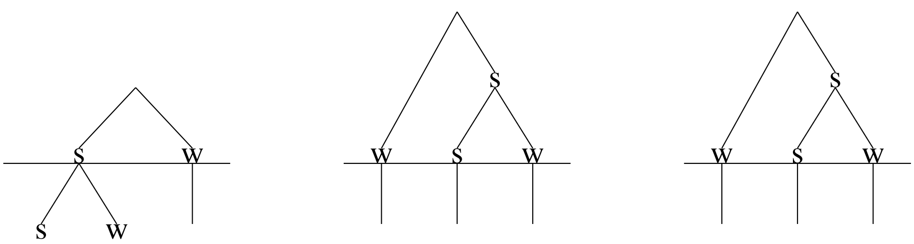


because there is only one syllable in this foot (/tɔn/), hence it is weak. To find the syllable that bears main stress, one has to follow the path of the strong constituents: *macaróni* and *márathon*.

Besides branching feet, non-branching superheavy syllables make a right constituent strong as well. This is illustrated in (8a): in *admirááI* ‘admiral’, the first syllable is closed (thus heavy), the middle (open) syllable has a long vowel and is light, and the last syllable is superheavy because of the long vowel followed by a coda consonant. Due to its weight, the last syllable is not allowed to be placed in the weak part of the foot, and thus has to form a foot by itself. The other two syllables can be grouped in another foot, since the heavy syllable is the head of the foot. Again, the word’s two feet are the only constituents of the main node, and LCPR determines which of the two is strong: the right constituent is strong, because this constituent dominates a superheavy syllable. *Admirááł* thus has final stress.

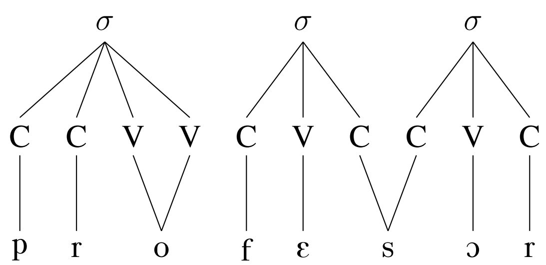
(8) a. ɑd mii raal b. ʃoo koo laa [+F]

Although Nouveau (1994) shows that there is definitely a regular stress grammar in our minds, some words just have a divergent stress pattern. Such cases are considered to be lexically marked by either a predefined foot or the combination of such a foot and a lexical marking [+F]. This last option is the case for the word (8b) *chocolá* ‘chocolate’, in which we find a predefined lexical foot on solely the last syllable, including a [+F] marking. Foot construction then only concerns the first two (open) syllables, both are grouped in one trochee. During the hierarchical ordering of the feet, LCPR prescribes that the foot dominating a [+F] marked syllable should be strong, even if it is not branching. This leads to final stress in *chocolá* as well.



(9) a. proo fɛ sɔr b. proo fɛs‿sɔr c. dee tɛk tɔr

Using this framework for stress, the need for linking ambisyllabic consonants to the preceding syllable is evidenced by words like *proféssor* ‘professor’: if the /s/ would only be onset to the last syllable, as in (9a), the pre-final syllable would be light (and ill-formed because the rhyme would contain only one element), and be placed in the weak position of the first foot of the word. This leads to the same representation as [ˈmaa.raa.tɔn], which we encountered in (7b) and results in antepenultimate stress. In order to obtain main stress on the proper syllable, we need a representation similar to (9c) *detéctor* ‘detector’, which is obtained in (9b) by requiring that the /s/ must be part of the middle syllable as well. This makes the middle syllable syllable as well, disallowing it to be placed in the weak position of a trochee. Hence, the last two syllables have to be each a foot on their own. The first syllable is placed in a monosyllabic foot as well, because there are no other syllables left to form a trochee with. In the word tree that is build from right to left, first the last two syllables are combined in one node, and then the first syllable is added in the top node. The node above /fɛsor/ is branching into /fɛs/ and /sɔr/, so this node is strong. The node above the foot /sɔr/ is not branching, therefore it is weak and the foot /fɛs/ is strong. This results in penultimate main stress. The syllable trees in (10) illustrate the representation of ambisyllabic consonants according to Van der Hulst (1985).

(10)


So, ambisyllabicity is required within this framework of metrical theory with word trees. However, one of the core assumptions for this theory – that is, the fact that all tense vowels are underlyingly long and all lax vowels are underlyingly short – has been falsified by Gussenhoven (2009). Based on acoustic measurements of Rietveld, Kerkhoff, and Gussenhoven (2004), Gussenhoven (2009) shows within an Optimality Theory framework that all vowels should be considered as underlyingly short. We will discuss his proposal in the next paragraph.

2.1.2.2 Dutch Stress within Optimality Theory

Optimality Theory (OT) is a branch within the generative grammar that does not work with a set of phonological rules, but with a universal set of constraints, present in all languages, and a language-specific ordering of these constraints (Prince & Smolensky, 1993). Given a specific input (an underlying representation of a word that is to be pronounced), a by principle infinite number of possible output candidates (surface representations) is generated by the generation module GEN. These output candidates are compared by the evaluation module EVAL against the constraints. Two types of constraints are available: markedness constraints, requiring the output candidate to match a specific form, and faithfullness constraints, requiring the output candidate to resemble the input representation. During the evaluation, starting with the highest ranked constraints, all candidates that violate a constraint are dropped out, until only one candidate remains. This candidate, although possibly violating a lower ranked constraint, is considered to be the optimal candidate, marked in the tableau by a pointing hand (☞), and this candidate is transferred to the phonetic device.

We can illustrate this by the following example of final devoicing (Grijzenhout & Krämer, 2000). In Dutch, all syllable-final consonants are devoiced, which means that /wɪnd/ 'wind' is pronounced [wɪnt]. In OT, final devoicing is regulated by the interaction of the constraints $*[+\text{VOICE}])_\sigma$ (11) and ID(VOICE) (12). The first of these two constraints is a markedness constraint and requires all syllable-final obstruents to be voiceless (literally: avoid voicing at the end of a syllable), and is violated if such an obstruent is voiced. The second constraint, a faithfulness constraint, requires that the voicing of an output candidate is identical to the voicing of the input. Changing the voicing property of a segment thus results in a violation. These two constraints conflict with each other, but the ranking of one above the other results in either final devoicing or not. For Dutch, the correct ranking is $*[+\text{VOICE}])_\sigma$ » ID(VOICE), shown in (13); for English the ranking should be reversed to remain [wɪnd] from /wɪnd/, as is shown in (14). So, the constraints are universal, but their ranking is language-specific.

(11) $*[+\text{VOICE}])_\sigma$ Syllable-final obstruents are voiceless

(12) ID(VOICE): Do not change the voicing property

(13)	/wɪnd/ (NL)	*[+VOICE])$_\sigma$ (11)	ID(VOICE) (12)
	a. wɪnd	*!	
☞	b. wɪnt		*

(14)	/wɪnd/ (EN)	ID(VOICE) (12)	*[+VOICE])$_\sigma$ (11)
☞	a. wɪnd		*
	b. wɪnt	*!	

In the measurements of Rietveld et al. (2004), it turned out that only tense vowels that are head of a foot are longer than lax vowels, but that tense vowels that are placed in the weak position of the foot have the same (short) duration as lax ones. In the strong position of the foot, only the tense vowels are long, lax vowels remain short. Gussenhoven (2009) proposes a constraint ranking in which length is represented by moraic weight (Hayes, 1989): tense vowels in the head of the foot project two moras, but only one mora if they occur in the weak position of the foot. Only the vowels that project two moras are pronounced as long vowels. Lengthening of vowels in the strong position of the foot is obtained by ranking SWP (23) above SYLMON (25). Underlyingly, all vowels are assumed to be short, and the [±tense] feature proposed by

(15) RHTROCHEE: In a foot, the first syllable is the foot head.

(16) NOCLASH: Foot heads should not be adjacent.

(17) FOOTBIN: Foot binarity: feet should contain minimally two moras and maximally two syllables.

(18) SONPEAK: The first two moras of a syllable must be [–cons].

(19) SHSP: SuperHeavy-to-Stress Principle: trimoraic syllables are strong foot heads.

(20) NONFIN: Main stress is not on the last syllable of the word.

(21) WBP: Weight-by-Position: coda consonants project a mora.

(22) WSP: Weight-to-Stress Principle: bimoraic syllables are foot heads.

(23) SWP: Stress-to-Weight Principle: foot heads are (minimally) bimoraic.

(24) PARSE-σ: All syllables should be placed in a foot.

(25) SYLMON: Syllables are monomoraic.

(26) F$_s$RIGHT: The strongest foot of the word should entail the rightmost syllable.

Van Oostendorp (1995) is used to distinguish the two types of vowels instead of [±long].

To ensure heaviness of closed syllables, as in the last syllable of *marathon* in (5b), coda consonants count as moraic weight as well due to WBP (21). To prevent these heavy syllables from being placed in the weak position of the foot, a high ranking of WSP (22) is required. Other important constraints that play a role in the creation of feet are RHYTHM-TROCHEE (15), ensuring that disyllabic feet are trochees instead of iambs and PARSE-σ (24), preventing that only one (main stress) foot is created. Furthermore, two constraints ensure disyllabic feet: FOOTBIN (17), demanding binarity of the feet and NOCLASH (16) disallowing foot heads to be adjacent (i.e. forbidding a series of monosyllabic feet and thus ensuring disyllabic feet). Finally, the interaction of NONFIN (20) and F_sRIGHT (26) make sure that main stress is, in general, located on the penultimate or antepenultimate syllable – unless the final syllable is superheavy, in which case the higher ranked constraint SHSP (19) demands this syllable to bear main stress.

The constraints (15) – (26) are placed in the proper ranking for Dutch. It goes beyond the scope of this paper to provide OT tableaus justifying all rankings, for now we restrict ourselves to the tableaus presenting words (5) – (9), although now with Gussenhoven's assumption of underlyingly short vowels.

In *macaróni* (27), only the vowels that are foot heads should be long vowels (/ma/ and /ro/), the other two vowels should remain short. This lengthening is only obtained by creating two feet, otherwise the other vowels will be lengthened too in order to satisfy WSP (cf. (27b), (27c)

(27)	/makaroni/	NOCLASH (16)	WSP/SWP (22) / (23)	PARSE-σ (24)	SYLMON (25)	F_sRIGHT (26)
	a. ˈ(maːka)(roːni)				**	*!
	b. maˈ(kaːro)(niː)			*!	**	*
	c. (maː)ˈ(kaːro)(niː)	*!			***	
	d. makaˈ(roːni)			*!*	*	
	e. (maka)ˈ(roni)		*!*			
☞	f. (maːka)ˈ(roːni)				**	
	g. (maː)(kaː)(roː)ˈ(niː)	*!***			***	
	h. (maːkaː)ˈ(roːniː)		*!*		****	

(28) /maratɔn/	NoClash (16)	NonFin (20)	WSP/SWP (22) / (23)	Parse-σ (24)	F_sRight (26)
a. maˈ(raːtɔn)			*!	*	
b. (maː)ˈ(raːtɔn)	*!		*		
c. ˈ(maː)(raːtɔn)	*!		*		*
d. maraˈ(tɔn)		*!		**	
e. (maːra)ˈ(tɔn)		*!			
☞ f. ˈ(maːra)(tɔn)					*

(29) /ɑdmiral/	NoClash (16)	SonPeak (18)	SHSP (19)	NonFin (20)	WSP/SWP (22) / (23)
☞ a. (ɑd.mi).ˈ(raːl)		*		*	
b. ˈ(ɑd.mi).(raːl)		*	*!		
c. (ɑd.mi).ˈ(ral)		**!		*	
d. ˈ(ɑd.mi).(ral)		**!			
e. (ɑd).ˈ(miː.ral)	*!	**			*
f. ɑd.ˈ(miː.raːl)		*	*!		*
g. ɑd.ˈ(miː.ral)		**!			*

or (27g)). Disyllabic feet are needed to satisfy NoClash, and penultimate stress is obtained by F_sRight. As (27f) does not violate any constraint except SylMon, which is violated by the other constraints as well, this candidate will become the surface representation.

In *marathón* (28), we see again that the last syllable is heavy and therefore cannot be placed in the weak part of the trochee: candidates (28a) – (28c) all violate WSP/SWP. The interaction of NonFin and F_sRight leads correctly to antepenultimate stress in (28f). Superheaviness is assured by SHSP » NonFin, allowing candidate (29a) to be more harmonic than (29b).

Just like (8b), exceptions should be handled by Optimality Theory as well. This is demonstrated in Gussenhoven (2014), by ranking a constraint that preserves lexical predefined feet with main stress above the constraints constructing the other feet in the word. In this way, underlyingly /ʃokoˈ(la)/ can become [(ʃoko)ˈ(laː)]. For the corresponding OT tableau and more possible ways of exception handling, we refer to Gussenhoven (2014).

Gussenhoven (2009) thus shows that vowels are lengthened as a result of foot construction and stress assignment, falsifying the assumption Van der Hulst made on underlyingly long tense vowels. Gussenhoven still makes use of ambisyllabicity, because he needs to prevent lax vowels from lengthening. This is done on the basis of LAX+C (30), a constraint token from Van Oostendorp (1995), that is violated if a lax vowel is not followed by a consonant within the same syllable. Combined with WBP (21), all lax vowels lead to heavy syllables (compare with tense vowels becoming only heavy if they are foot heads). Combined with ONSET (31), that satisfies the MAXIMAL ONSET PRINCIPLE, intervocalic consonants after a lax vowel become ambisyllabic, as in *proféssor* (32d)[1]. In closed syllables with a tense vowel, e.g. (33) /lot/ 'draw lots (1SG)', where the /t/ is a coda that projects a mora due to WBP (21), vowel lengthening would be blocked because the syllable is already bimoraic. To ensure its lengthening, SONPEAK (18) demands the first two moras of a word, if present, to be vocalic. This constraint is ranked below LAX+C in order to effect only tense vowels (cf. (34)).

As mentioned in the introduction of this paragraph, the weight of a syllable is represented by moras (Hayes, 1989). Within moraic theory, the syllable trees do not consist of onsets,

(30) LAX+C: A lax vowel is monomoraic ans must be followed by a consonant within the same syllable.

(31) ONSET: A syllable must have an onset.

(32)	/profɛsɔr/	ONSET (31)	LAX+C (30)	SONPEAK (18)	WSP/SWP (22) / (23)	F_sRIGHT (26)
	a. pro.ˈ(fɛ.sɔr)		*!		*	
	b. pro.ˈ(fɛː.sɔr)		*!		*	
	c. pro.ˈ(fɛs.ɔr)	*!		*	*	
☞	d. pro.ˈ(fɛs.sɔr)			*	*	
	e. pro.ˈ(fɛːs.sɔr)		*!		*	
	f. ˈ(proː.fɛs).(ɔr)	*!		*	*	*
	g. (proː.fɛ).ˈ(sɔr)		*!			*

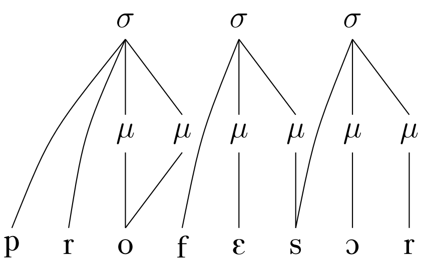
[1]The ambisyllabicity of the /s/ is represented as [s.s], although this is just one segment.

(33) /lot/	ONSET (31)	LAX+C (30)	SONPEAK (18)	WSP/SWP (22) / (23)	SYLMON (25)
a. lot			*!		*
☞ b. loːt					**

(34) /lɔt/	ONSET (31)	LAX+C (30)	SONPEAK (18)	WSP/SWP (22) / (23)	SYLMON (25)
☞ a. lɔt			*		*
b. lɔːt		*!			**

nuclei and codas, nor of consonants and vowels, but only consist of a syllable node and weight-carrying moras. The representation of *professor*, with ambisyllabic /s/, is given in (35).

Ambisyllabicity is preserved in Gussenhoven (2009), even though the assumption on vowel length of Van der Hulst (1984) is falsified. Gussenhoven has not investigated whether ambisyllabicity should still be included in his analysis, but the notion of ambisyllabicity is not unchallenged though.

(35)


2.1.3 Ambisyllabic controversy

After Kahn (1976), other scholars have proposed ambisyllabic solutions to phonological questions too, among which we find Gussenhoven (1986a) and Rubach (1996) for English, Borowsky, Itô, and Mester (1984) for Danish and Wiese (1996) for German. Many of the proposals of the above mentioned authors have been challenged in a critical review by Jensen (2000). He claims that the evidence for English ambisyllabicity as has been provided by Rubach (1996) is weak and can be avoided by using prosodic categories within the phonological rules. One example of this is /r/-tapping, which has been claimed by Rubach (1996) to occur only when it is ambisyllabic. Jensen (2000, p.195) shows that a bleeding tensing rule that is only applied foot-initially takes all contexts for /r/-tapping away, which is only applied to a /r/ that is [–tense].

In order to account for other phenomena in English, such as schwa insertion or compensatory syllabification, Jensen (2000) applies a foot structure in which unfooted syllables are adjoined to an existing foot. The word *potáto* is an illustration of a word in which this adjunction is applied: this word is initially footed as *po(tato)*, and then the first syllable is adjoined to this foot: *(po(tato))*. This contrasts with Gussenhoven (1993), who suggests that for Dutch an unfooted (thus unstressed) initial syllable should not be footed. The reason for Jensen to do so, is that he can now distinguish between minimal feet (i.e. a foot that does not dominate other feet: *(tato)*) and maximal feet (i.e. a dominating foot: *(po(tato))*), a distinction that is necessary to account for compensatory syllabification, which occurs only within minimal feet.

More interesting is the reanalysis of German vowels Jensen (2000) proposes. Like Dutch, German is analyzed as having an opposing distribution of long/tense and short/lax vowels such that a lax vowel does not occur in open syllables and that intervocalic consonants following lax vowels are ambisyllabic (Wiese, 1996). Jensen (2000, p.221) presents three problems with this analysis, mainly focused on the underlying representation of ambisyllabic consonants. As we will see in section 2.2.1, this underlying representation of ambisyllabic consonants is exactly the same as geminate consonants, although ambisyllabic consonants are realized as short consonants and geminates as long ones.

Jensen's first problem with German ambisyllabicity is that the language has no durational oppositions between long and short consonants, so why representing some of them in the same way as long consonants are represented? Second, German has, just like Dutch, a syllable-final devoicing rule, and also German ambisyllabic consonants are not devoiced by this rule. In English, preglottalisation is a phenomenon that applies to both coda and ambisyllabic consonants Gussenhoven (1986a). So, there seems to be an inconsistency in when ambisyllabic consonants are considered as true coda consonants (i.e. English) and when not (Dutch and German). By taking ambisyllabicity away, this inconsistency is lost as well. Finally, in German stress assignment, coda consonants are treated differently from ambisyllabic consonants: when the penultimate syllable has a true coda consonant, main stress is always on this syllable, while with a ambisyllabic consonant between the penultimate and final syllable, main stress can be both penultimate and antepenultimate.

So, for English, German and other languages analyzed by Jensen, the notion of ambisyllabicity turns out to be quite controversial and seems not always necessary to account for the observations. For Dutch, ambisyllabicity is still incorporated in the phonological theory – although in Chapter 5 we will revisit the arguments of Van der Hulst (1984, 1985) and Jensen (2000) again and verify their validity in the light of the results we obtained from our experiments. As touched upon above, the representation of ambisyllabic consonants is identical to the representation of geminate consonants. We will therefore continue this chapter with a discussion of gemination and, as has been assumed to be the case for Dutch, degemination.

2.2 Geminates and Degemination

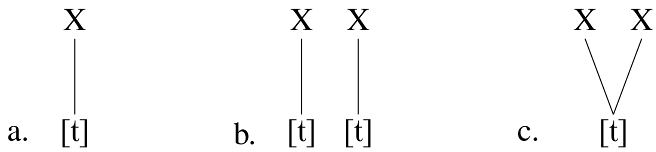
In many languages (e.g. Italian (Stevens, 2011), Korean (Cho, 2001) or dialects in Swiss German (Ham, 1998) or Arabic (Abu-Abbas, Zuraiq, & Abdel-Ghafer, 2011)), there is a contrast between short and long consonants. The canonical example of this contrast is Italian [fato] 'fate' versus [fatːo] 'fact'. In other languages, such as Dutch (e.g. Booij, 1995, but see section 2.3 for more), all possible contexts for long consonants (geminates) are neutralized, leading to homophony of /plɑn/+/tɛid/ 'planning time' and /plɑnt/+/tɛid/ 'planting time', both pronounced as [plɑntɛit][2] In this section we will review the properties of a geminate, as well as the possible structural representations of geminates, fake geminates and degeminated consonants.

2.2.1 True Geminates

True geminates are considered to be present in the lexicon, while fake geminates are the result of a coincidental occurrence of a morpheme ending in the same consonant as the initial consonant of the following syllable (Abu-Abbas et al., 2011). Abu-Abbas et al. provide a thorough overview of the properties and the representations of geminates.

Within *SPE* (Chomsky & Halle, 1968), geminates were distinguished from their short counterparts by means of the binary feature [±long]. With the emergence of metrical theory, the discussion on how to represent a geminate arose as well. Based on the fact that single consonants are, within X Theory (Hayes, 1989), represented by one segment attached to one time

[2]Note that the change from /t/ to [d] in /tɛid/ has nothing to do with degemination, but is the mere result of final devoicing as discussed in section 2.1.2.2 on page 13.

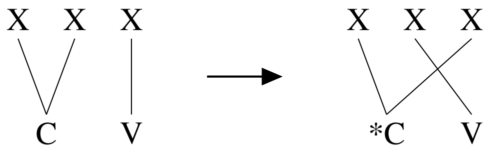
(36) 

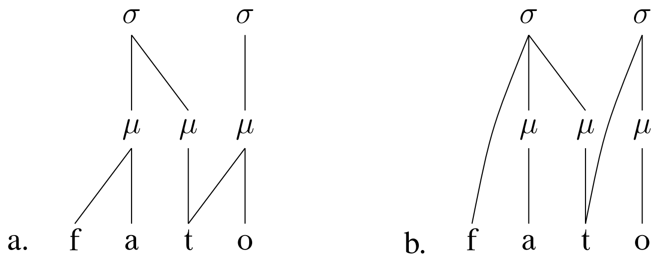
slot (36a), geminates could either be represented as two segments attached to one time slot each (36b) or one segment attached to two time slots at the time (36c). The representation in (36b) is defended by Delattre (1971), qualifying geminates as a re-articulation of the same consonant, where the first should be considered as coda of the previous syllable and the second as onset. Geminates are thus assumed to be two elements, with two phases in the articulation. "A diminution of the muscular tension", thus a phonetically visible separation between the two elements of the geminate is also observed by Debrock and Mertens (1990, p.42), confirming representation (36b).

Delattre (1971) uses representation (36c) as well, not for geminates but for long consonants. Delattre claims that, opposed to geminates, long consonants are only one segment occupying two time slots, thus without the separation between the two segments. According to him geminates are the result of phonological processes such as vowel deletion, while long consonants are located within the lexicon.

Opposed to Delattre (1971), we find several scholars proposing representation (36c) for geminates (Loporcaro, 1996; McCarthy, 1979). We too prefer representation (36c), based on what Kenstowicz and Pyle (1973) call the phonological integrity of geminates. They studied a range of languages that manifest a restriction on the application of certain phonological rules, e.g. metathesis (37) in the formation of the past tense in Sierra Miwok (Kenstowicz & Pyle, 1973, p.30). This restriction blocks metathesis when this would lead to a splitting of the geminate. As this type of integrity conditions occurs in several other languages too, Kenstowicz and Pyle argue for an universal integrity property of geminates, as an universal property is less arbitrary than adding a condition to language-specific rules. By assuming (36c) for geminates, this integrity property becomes implicit as the WELL-FORMEDNESS CONDITION (Goldsmith, 1976) forbids the association lines between time slots and segment to cross each other. Metathesis of (37) without the integrity condition would then lead to the ill-formed representation (38).

(37) METATHESIS: $C_1\ C_2\ V]_{past} \rightarrow C_1\ V\ C_2$ Condition: $C_1 \neq C_2$

(38) 

(39) 

Within moraic theory, two almost identical representations are observed: (39a) and (39b). Both representations of *fatto* have a geminate [t], but in (39a) all segments are attached to moras, while in (39b) all onset consonants are directly connected to the syllable node. A representation of *fato*, without geminate [t], would be the same as both representations in (39), but without the [t] being attached to the mora directly above it. The [t] would then only be connected to the mora (representation a) or syllable node (representation b) of the second syllable. Representation (39a) is preferred by Jensen (2000), based on the STRICT LAYER HYPOTHESIS (Selkirk, 1986). This hypothesis states that a prosodic unit should always be contained within the unit directly above it in the prosodic hierarchy. However, Jensen violates this same constraint when he proposes a distinction between minimal and maximal feet, where a foot can be dominated by another foot, which is thus not a prosodic unit directly above it in the hierarchy. As such, we prefer representation (39b), proposed by Hayes (1989). Since moraic units show the weight of a syllable and onset consonants do not contribute to this weight, there is no logic to connect onset consonants to a mora.

Regardless of the discussion to which layer an onset consonant should connect, the resulting representation for geminates is identical to the representation of ambisyllabic consonant [s] in (35). Ambisyllabic consonants differ from 'regular' consonants in their representation, but a duration distinction between these two is not known. For geminate consonants, the duration is longer, a geminate having a duration of varying from 150% to 300% of the single consonant (Abu-Abbas et al., 2011; Ham, 1998).

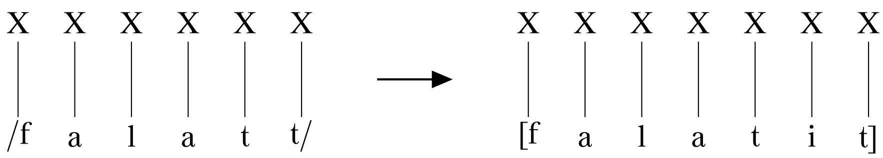
We mentioned above that we prefer representation (36c) for geminates and (36b) for so-called fake geminates. We will now turn to the category of fake geminates.

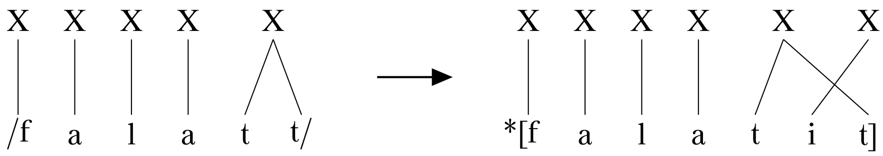
2.2.2 Fake Geminates

In many languages, we can find combinations of morphemes where the first morpheme ends in the same consonant as the initial consonant of the following morpheme. These combinations, though not part of the language's lexicon, resemble geminates when it comes to their surface length (Oh & Redford, 2012; Ridouane, 2010), but their representation should be considered differently.

Evidence for this claim comes from Arabic, where true (lexical) geminates resist vowel epenthesis, but when two identical consonants are the result of morpheme combinations, vowel epenthesis is allowed. This occurs in both (40) Palestinian Arabic (Hayes, 1986) and (41) Jordanian Arabic (Abu-Abbas et al., 2011). This means that the integrity hypothesis of Kenstowicz and Pyle (1973) is not applicable if the geminates are fake geminates, and that underlying the structure thus must be like (42), and not like (43).

(40)	Palestinian:	/fut+t/ → [futit]	'I entered'
(41)	Jordanian:	/falat+t/ → [falatit]	'I escaped'

(42) 

(43) 

Within West-European languages, fake geminates have been explored in English and French. In French, consonants are generally not lengthened, even not in a context of two identical consonants, except when an ambiguity could arise (Tranel, 1987). Therefore, the future tense of *courrait* 'to run' is sometimes pronounced [kuʁʁɛ] with a long [ʁ], opposed to the past tense of the same verb (*courait* [kuʁɛ]) with short [ʁ]. Besides inflection morphology, we can find longer consonants after schwa deletion (*la dent* [ladã] 'the tooth' versus *là-d(e)dans* [lad(ə)dã] 'there in it'; Tranel (1987)), across word boundaries (*il a dit* [iladi] 'he said' versus *il l'a dit* [illadi] 'he said it'; Meisenburg (2006)) or word-internally across morpheme boundaries, as with some prefixes (like *in-* or *com-* followed by another nasal; Yaguello (1991)). Meisenburg (2006) performed a production and perception experiment to test whether differences between the two ambiguous contexts is perceptible or not, her results show that none of the ambiguous contexts are consistently lengthened, and therefore none are consistently correctly perceived. She therefore concludes that gemination in French is optional and not phonological, and only used for the sake of clarity to the listener.

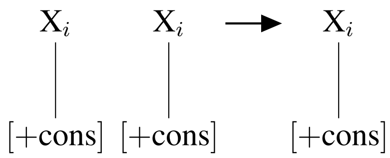
In English, fake geminates may also arise word-internally across morpheme boundaries as well as between words across word boundaries. Oh and Redford (2012) have performed production experiments to test for duration differences between these two contexts. Their results show that the absolute durations of both types of fake geminates were longer than single consonants, but that the relative duration (the duration of the geminate compared to the duration of the preceding vowel) was longer for word-internal fake geminates, while fake geminates across word boundaries had an equal relative duration as single consonants.

For Dutch, it is assumed that all sequences of identical consonants are degeminated into one single consonant (Gussenhoven, 1992). In the next section we will look at the degemination proposals that have been offered in the last two decades.

2.2.3 Degemination

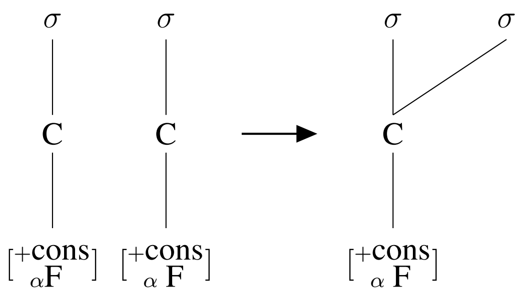
Through the literature, we encounter many examples of degemination rules for Dutch, although the exact working of this process is not always clear: "The rule of Degemination deletes one of two adjacent identical consonants" (Booij, 1995, p.69; Gussenhoven, 1992; Martens & Quene, 1994), without stating which one should be deleted. If at least some specification on this process is given, it is most frequently the first of two identical consonants that is affected by degemination (Ruys & Trommelen, 2003). Within the *SPE*-framework, rule (44) has repeatedly been proposed (Gussenhoven and Jacobs 2013, p.101, Trommelen & Zonneveld, 1979), again deleting only the first of two identical consonants. Within the autosegmental phonology, Booij (1995, p.69) proposes (45), where it is not clear which of the two segments is deleted.

(44) DEGEMINATION: $\underset{1}{[+\text{cons}]}\ \underset{2}{(\#\#)}\ \underset{3}{[+\text{cons}]} \rightarrow \emptyset\ 2\ 3 \quad (\text{Condition:} 1 = 3)$



(45) DEGEMINATION: Domain: obligatory within prosodic words, optional in other domains

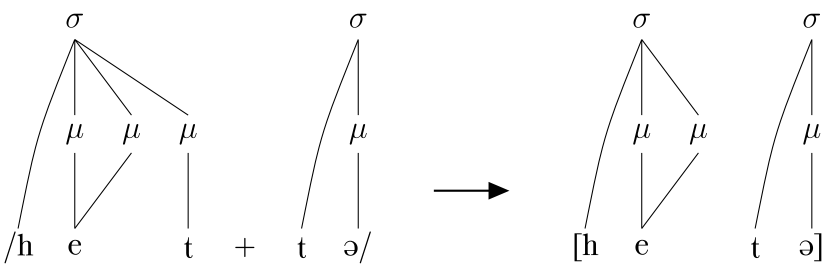
(46) DEGEMINATION:



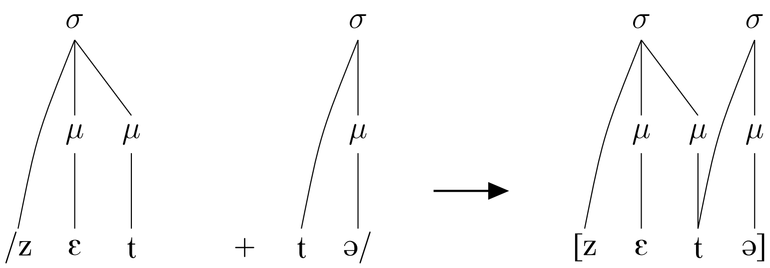
Simply deleting one of the consonants means deleting either the coda or the onset. Gussenhoven (1986b) shows that if the coda were to be deleted, this would effect the preceding vowel, and that if the onset were to be deleted, homophony between *vier regels* 'four rules' and *vier egels* 'four hedgehogs' would incorrectly be predicted. Therefore, he proposes to consider degemination as a resyllabification rule, expressed in (46). In all of these rules, degemination considers [+cons] segments, which excludes glides from degemination.

A complicating factor in the formulation of the correct degemination rule is the ambisyllabic

(47)



(48)



status of intervocalic consonants following lax vowels: in both verb roots *heet* 'be called.1SG' (47) and *zet* 'put.1SG' (48), the /t/ has the same configuration, that is, a mora projecting coda consonant. However, when these roots are followed by the past morpheme /tə/, and degemination applies, the remaining [t] in *zette* (48) has become ambisyllabic, while the remaining [t] in *heette* (47) is only an onset consonant. Rules (44) and (45) would predict onset consonants in both *heette* and *zette*, while rule (46) predicts for both words an ambisyllabic configuration. A proper degemination rule should take this difference into consideration as well, but as far as we know, the different representations of *heette* and *zette* have not been addressed in the literature before.

Still, most scholars seem to agree on the fact that Dutch has some degemination process though. However, the degree of degemination – is it either gradient or complete – is not always clear. In the next section, we will look at experimental studies that address the gradient/categorical discussion of degemination – studies that should be seen as predecessors of the experiments we performed in this thesis.

2.3 Previous studies

Experimental studies to Dutch degemination include only one production study, one perception study and one study that combines both production and perception.

The first production experiments are from Martens and Quene (1994). They asked one participant to produce 12 minimal pairs at three different speech rates. These minimal pairs consisted all of either a single or a double voiceless fricative (/f/ or /s/), of the type *zee fijn* /ze#fɛin/ 'sea fine' versus *zeef fijn* /zef#fɛin/ 'sieve fine'. Both the length of the fricative and the preceding vowel were measured, in order to obtain absolute and relative durations. The authors found a significant difference of both the absolute and relative duration between single and double fricatives, but as the duration difference between the vowels was less than the difference between the consonants, it was concluded that the differences between the relative durations were mostly due to the differences in absolute durations. The authors also found that the absolute duration of double fricatives was almost twice the duration of single fricatives in a slow speech rate, while in fast speech, the average difference between those two was only 9 milliseconds. Hence, Martens and Quene conclude that degemination is a gradual phenomenon, just like speech rate is gradual, and that degemination is never complete. The fact that non-complete degemination (thus geminates) in a language might conflict with ambisyllabicity is not discussed by these authors.

As other gradual phenomena such as voice assimilation turned out to be perceived as complete in fast speech rates (Menert, 1994), the difference of 9 ms. was reason for Te Riele, Loef, and Van Herwijnen (1997) to perform a perception experiment on data similar to Martens and Quene (1994)'s experiment. Te Riele et al. used 10 of the 12 minimal pairs of Martens and Quene, all produced on a fast speech rate, and tested the perception of these pairs by 40 participants. The experiment consisted of three tasks, in which the participants heard resp. the carrier phrase up to including the vowel preceding the ambiguous consonant (e.g. [ze]), the sentence up to including the ambiguous consonant itself (e.g. [zef]) and the entire carrier phrase from begin until the end (e.g. [zefɛin]. In each part, the participants had to indicate which part of the minimal pair (single or double fricative) they heard, by means of a binary forced choice. If there would be any acoustic cue in the vowel, the authors expected correct identifications of the phrases in the first task, if there would be only acoustic cues in the consonant, they expected correct identifications in the second task. If there would not be any cue present at all, the percentage of correct responses in the last task should not exceed chance level. Te Riele et al. found that these percentages did indeed not exceed chance level. As the only significant relation of the number of correct responses to the third task was with the word frequency, the authors concluded that none of the acoustic cues could improve word recognition, and that word frequency played a subtle role, but not enough to exceed chance level.

The most recent study to degemination is Jacobs, Kerkhoff, and Greefhorst (to appear), in which two production and one perception study have been performed. Similar word pairs as Martens and Quene (1994) were used, but besides fricatives, also plosives, liquids and glides were included. The results of their production experiments show significant differences between all single and double consonants, although single/double plosives and glides differed on average only 14-20 milliseconds (ms), while single/double fricatives and liquids differed about 40 ms. In their perception experiments, the correct identification scores of plosives did not exceed chance level, while this score for all fricative pairs with a difference between single and double fricative of more than 20 ms (i.e. 75% of their minimal pairs) did so. Hence, they conclude that degemination should be considered complete for plosives, but not for fricatives. Furthermore, their results show no duration differences between single fricatives across word boundaries, word-internal onset single fricatives and word-internal ambisyllabic fricatives. As such, they propose to abolish the ambisyllabic state of intervocalic consonants (because in the production there seems to be no difference between the two types of word-internal consonants), and to use instead an ambisyllabic/geminate construction for double fricatives across word boundaries.

2.4 Research Questions

In this chapter, we have seen that there still remain some unanswered questions in the literature on ambisyllabicity and degemination. First, the exact working of degemination is unclear: it seems that there are two outcomes of degemination, either an onset consonant as in *heette* (47) or an ambisyllabic consonant in *zette* (48). How should we account for this difference? Moreover, is there any difference between degeminated ambisyllabic consonants and lexical ambisyllabic consonants, such as in *kappen* /kɑpə/ 'to hijack'?

Second, what is the domain of degemination for Dutch? The proposals we have seen until now (Booij, 1995; Gussenhoven, 1986b; Gussenhoven & Jacobs, 2013) state that degemination is only applicable for [+cons] segments, thus plosives, fricatives, liquids and nasals, but not for glides. However, Jacobs et al. (to appear) show that glides are degeminated as well, while fricatives are not. To find out which segments are degeminated and which not, a thorough study including all consonant of Dutch should be conducted. Furthermore, the results of Jacobs et al. (to appear) are only based on speakers from the Nijmegen region. Are there results valid for other Dutch speaking regions as well? For instance, could glide degemination be affected by the allophonic variation between syllable-final [β] and syllable-initial [ʋ], an allophony that is not present in the Nijmegen region? (Goossens, Webber, Taeldeman, & Verleyen, 2000)

A third question concerns the status of ambisyllabic consonants. If consonants are not shortened, as seems to be the case for fricatives (Jacobs et al., to appear), what would the representation of these consonants be? Should they be considered as fake geminates, like in English Oh and Redford (2012), or could we obtain a geminate structure as in (36c)? A geminate structure would be a welcome argument against ambisyllabicity, as having both ambisyllabicity and true geminates within the same language would lead to opaque duration differences. On the other hand, if the longer duration for fricatives were the result of fake geminates, we could still propose the abolition of ambisyllabicity: the main assumption for it – i.e. underlyingly long vowels (Van der Hulst, 1985) – was already falsified by Van Oostendorp (1995) and reused in a theory for Dutch stress by Gussenhoven (2009), and none of the other arguments seem very convincing.

In the remainder of this thesis, we will look at production and perception experiments that have been carried out throughout the Netherlands. These experiments will shed light on the above mentioned questions, by fully examining the degemination process at four different geographic locations within the Netherlands, in which all Dutch consonants are used in minimal pairs. After presenting the methodology and the results of these experiments, we will come back to the questions above, so we can see if ambisyllabicity should still have a role in the phonology in Dutch.

Chapter 3. Production experiment

The research questions raised at the end of the previous chapter will be addressed as follows. We start with the second question, that demands a thorough comparative study of Dutch intervocalic consonants. Only after answering this question, we move on to the more theoretical implications involving the effects of degemination (i.e. research question 1) and the phonological status of intervocalic consonants (i.e. research question 3). In the present and the following chapter we will report on the study on Dutch intervocalic consonants. The potential phonological implications will be addressed in Chapter 5.

In order to address the second research question, we started by a production experiment. In this experiment, participants were asked to pronounce minimal pairs that allow for a comparison between the durations of single and double consonants. If we would find no (significant) durational difference between these two, degemination could be considered complete. As concluded by Te Riele et al. (1997) and Jacobs et al. (to appear), even if durational differences between single and double consonants occur, it might still be the case that these difference are small enough to not be perceived by native speakers. In that case, degemination can still be considered to be perceptually complete as well. On the other hand, if participants could distinguish between the words of a minimal pair, while in fact there were no (significant) durational cues, we will have to assume that other acoustic cues play a role. So, regardless of the results of a production experiment, we need a perception experiment to confirm the observations of the production experiment.

The present chapter is dedicated to this production experiment. We start by defending our methodology in the first section, then we present our results in the second section, and we finish this chapter by a brief discussion of the production results. The following chapter, Chapter 4, will report in a similar way on the perception experiment that followed afterwards.

3.1 Methodology

In the previous chapter, we have seen two production experiments involving Dutch intervocalic consonants (Jacobs et al., to appear; Martens & Quene, 1994). Neither of these two are satisfying, because both have their weaknesses. Martens and Quene (1994) used only one speaker, and focused on only two types of fricatives (i.e. [f] and [s]). Jacobs et al. (to appear) used 13 speakers from the southern regions of the Netherlands (including Belgium Dutch speakers), which does not allow for generalizations to the entire Dutch speaking community. We believe that the methodology described below can be considered an improvement to the deficits of these two studies. This section starts by describing the participants of this study, followed by a presentation of the stimuli, and ends with an outline of the statistical analysis.

3.1.1 Participants

In order to obtain a data set that allows for a generalization to all speakers of Dutch, three different geographical regions of the Netherlands were selected:

- from the south-east of the Netherlands: Uden (Province: North-Brabant);
- from the south-west of the Netherlands: Zierikzee (Province: Zeeland);
- from the nord-east of the Netherlands: Zwolle (Province: Overijssel);
- and from the nord-west of the Netherlands: Amsterdam (Province: North-Holland).

In all four regions/cities, teachers of secondary schools were asked if it would be possible to include their fourth- and five-grader VWO students (pre-university college) in the experiment. The choice for these junior participants was made because these the risk of including dialects from other sides of the country would be reduced, compared to speakers of a higher age. However, since some of the stimuli (cf. next subsection) included highly rare word bi-grams[1], which could cause hesitation if the speaker's vocabulary is not large enough, we only included students from the last three years of their secondary school.

[1]A word bi-gram is the combination of two consecutive words

In the first three regions (Uden, Zierikzee and Zwolle), we received very positive reactions from teachers at their local secondary school. At each of these schools, we selected 12 participants with Dutch as only native language. In the last region (Amsterdam), we did not receive positive reactions (if we received anything at all), hence we had to adapt our selection criteria for this region. Therefore, we asked students from the University of Amsterdam to participate in this experiment. Speakers that did not grow up in the large region of Amsterdam, that did not not live in the city of Amsterdam within the last five years or that had a clearly audible accent from another region were excluded afterwards, hence we had only 11 recordings for this location. The total number of participants was 47, of which 22 were male and 25 were female.

3.1.2 Stimuli

For this experiment, two types of minimal pairs were created in order to measure the length of single and double intervocalic consonants: the first type of pairs aimed to test the effects of degemination, the second type of pairs aimed to test the effects of lexical ambisyllabic consonants.

Within the degemination pairs, the first item of a pair consisted of a word ending in a consonant followed by a word starting with the same consonant (e.g. *piekkoorts* /pik+korts/ 'peak fever'), the second item consisted of the same bi-gram, except that the first word did end in a vowel instead of a consonant (e.g. *pi-koorts* /pi+korts/ 'pi fever'). Where possible, words were written as compounds without any orthographic separation between the words (as in *piekkoorts*), but where we expected different pronunciations, we either introduced a white space or hyphen. For instance, leaving out the hyphen in *pi-koorts* could possibly have led to a pronunciation with a lax vowel (e.g. [pɪkorts]), creating a non-comparable context. We selected all consonants of Dutch that can occur both word-finally and word-initially. Due to word-final devoicing, we could not include voiced consonants in this experiment. The final selection of 27 minimal pairs contained 6 plosive pairs (i.e. [p], [t], and [k]), 9 fricative pairs([f], [s], and [x]), 4 nasal pairs ([m] and [n]), 4 liquid pairs ([l] and [r]) and 4 glide pairs ([j] and [w]). A glossary of all words that have been used in the experiments can be found in Appendix A on page 77.

Besides minimal pairs containing contexts that favor degemination, we included 5 minimal pairs comparing lexical ambisyllabic consonants with regular intervocalic consonants (i.e. resp. *kappen* /kɑpə/ 'to chop' versus *kapen* /kapə/ 'to hijack'). Although Van der Hulst (1984) claimed that even though the underlying structure of the intervocalic consonant is different in these two words, the only recent study of these structures is Jacobs et al. (to appear), which measured only fricatives. Hence, we decided to measure this difference for the other manners of articulation. This includes 3 plosive pairs, 1 nasal pair and 1 liquid pair. Since we were unable to construct such minimal pairs for glides, we only included the words *sproeien* /sprujə/ 'to spray' and *duwen* /dywə/ 'to push'.

3.1.3 Procedure and analysis

The 27 degemination pairs, 5 ambisyllabic pairs and 2 additional words containing a single glide led to 66 individual words. 14 more words were used as fillers, distracting the attention of the participant from the minimal pairs. These 80 words were all placed in the same carrier phrase *Ik ZEG ... niet* 'I SAY ... not (I don't say ...)'. Participants were asked to emphasize the word *ZEG*, in order to reduce effect of stress on the focus words. Effects of the word list were taken away by creating four different versions of the same list: version one and two were randomized versions of the same 80 phrases, version three and four contained the reverse order of resp. version one and two.

At each location, the participants were asked to read aloud one of the four versions of the list, while being recorded. The experiment took place in a quite room, eliminating disturbing noises as much as possible. Recordings were made by means of MB Quartz MKB C 800 headsets, which have their microphone close to the speaker's mouth, again reducing any surrounding noises. All participants were asked to read the list before they started the recording, and to ask for clarifications if he or she did not know how to pronounce a word.

The 47 recordings were analyzed in Praat (Boersma & Weenink, 2009), in which a wave form and spectrogram of the recording were created. Inspecting these two graphs allowed to determine the exact length in milliseconds of the focus consonant (either the single, double or ambisyllabic consonant). As Oh and Redford (2012) showed that, at least for English, the relative duration of the consonant compared to the preceding vowel can distinguish word-internal fake geminates from fake geminates across word boundaries, we measured the length of the preceding vowel as well. From the vowel lengths, relative consonant durations can be calculated by dividing the absolute consonantal length by the vowel length. We calculated the absolute and relative durations for all 66 words of 47 speakers, resulting in 3102 absolute durations, and an equal amount of relative durations.

We first looked at the degemination pairs, and calculated for each manner of articulation the mean absolute and relative duration of the single and of the double consonants. Then, we tested whether the differences in both durations were statistically significant, taking into account the possible effects of manner of articulation, list version, geographical origin and possible interactions between these factors. Significance is reached if $p < .05$, meaning that the probability of finding the observed effect(s) by chance is less than 5%. As all predictors were categorical, we used a factorial analysis of variance (ANOVA) to test their effects. Based on the literature discussed in Chapter 2, we expected a non-significant result for plosives, but as discussed in Section 2.4, the results for fricatives, liquids and glides are contradictory, hence we cannot foresee the outcome yet.

Afterwards, we compared the absolute and relative durations of the ambisyllabic pairs, again controlling for the same effects and using a factorial analysis of variance as well. Based on the literature, we expected no differences in absolute duration between single and double consonants.

In the next section, we will present and discuss our results.

3.2 Results

We have tried to measure the absolute and relative duration of 3102 words, produced by 47 participants dispersed over four different regions of the Netherlands. From these productions, we had to excluded 292 recordings of words that were either a mispronunciation, contained a pause between the two focus words, or were elsewise not analyzable. The 2810 remaining recordings contained fluent speech. Among these recordings, we had 1067 measurements of word pairs ending in a consonant followed by a word starting with the same consonant, and 1192 measurements of a single intervocalic consonant across word boundaries. The other 551 recordings came from ambisyllabic pairs. For reasons of space, we will not print the exact durations of all these measurements, but we limit ourselves to a presentation of the averages and the corresponding statistical analysis. For a detailed overview of all individual measurements, we refer to Appendix B; the degemination pairs are reported on page 81 and further, the ambisyllabicity pairs are reported starting on page 94. We will first present the average durations of the degemination pairs, the results of the ambisyllabic pairs follow afterwards.

3.2.1 Degemination

By using the analysis of variance with absolute duration as dependent variable and number of consonants, manner of articulation and geographical region as independent variables, we tested the influence of the three variables (and the four possible combinations of these variables, i.e. the interactions) on the duration of a consonant. The analysis thus tested if a variable or interaction could possibly explain why some consonants are longer while others are shorter, though our research questions only concern the effect of the number of consonants and the interactions of this variable with the other ones. For instance, the main effect of the geographical region only tells us if consonants in a specific region are *generally* longer or shorter that in other regions, while we are more interested in the interaction of this region with the number of consonants (i.e. is it the case that only in some regions there is a difference between single and double consonants?). The same holds e.g. for the interaction of geographical region and manner of articulation, which tests if only some consonants are *generally* longer or shorter in a specific region, while other consonants or other regions have more or less equal consonant durations. This interaction does not involve the difference between single and double consonants, and thus does not answer our research question. As such, we will only report on the statistics that are relevant to our research question.

Table 3.1 shows the mean absolute durations for single and double consonants for each manner of articulation, as well as the difference between these two durations. The significant main effect of number of consonants ($F(1, 2220) = 279,\ p < .001,\ \omega^2 = .07$) indicated that on average, double consonants ($M = 121$ ms, $SD = 51$ ms) are statistically longer than single consonants ($M = 96$ ms, $SD = 32$ ms). In other words, the overall durations suggest that in Dutch, degemination would not be complete.

The analysis of variance also tested the interaction of the number of consonants with the two other variables. Three combinations are possible, but only the interaction between number of consonants and manner of articulation was significant ($F(4, 2220) = 5.2, p < .001$). The other two interactions were not significant. This concerns the interaction between geographical region and number of consonants ($F(3, 2220) = 2.4, p = .07$), and between the three variables all together ($F(12, 2220) = 1.6, p = .08$).

Manner	Single		Double		Diff.	Statistics
Plosive	115 ms.	$(N = 262)$	145 ms.	$(N = 202)$	30 ms.	$F(1, 456) = 86, p < .001$
Fricative	115 ms.	$(N = 393)$	149 ms.	$(N = 352)$	34 ms.	$F(1, 737) = 125, p < .001$
Nasal	77 ms.	$(N = 182)$	99 ms.	$(N = 171)$	22 ms.	$F(1, 345) = 82, p < .001$
Liquid	64 ms.	$(N = 175)$	81 ms.	$(N = 179)$	17 ms.	$F(1, 346) = 31, p < .001$
Glide	78 ms.	$(N = 180)$	99 ms.	$(N = 164)$	21 ms.	$F(1, 336) = 51, p < .001$

Table 3.1: Mean absolute durations of the focus consonants, all given in milliseconds.

The interactions give more insight in the application of degemination. Although generally, double consonants are longer than single ones, the only significant interaction suggests that this might be the case for only some of the manners of articulation. For other manners of articulation, degemination could thus perhaps be complete. In order to test this, the analysis has been split by manner of articulation. The corresponding statistics are given in the last column of Table 3.1. As for all five manners of articulation, the difference is significant, the significant result of the interaction should be interpreted as follows: though the difference between single and double consonants is for some manners of articulation larger than for others, all double consonants are significantly longer than shorter consonants. In other words, for all manners of articulation, there seems to be a difference in absolute duration between single and double consonants. This could possibly mean that degemination is thus never applied for any of the manners of articulation, though this is to be confirmed by an analysis of the relative durations, which will be conducted below.

The non-significant interactions are also highly informative. The fact that the interplay of geographical region and number of consonants has no (significant) importance means that our results are valid for all geographical regions that we included in the analysis. As our sample contained speakers from all four corners of the country, it becomes tempting to say that our findings might be generalized to the entire Dutch speaking community in the Netherlands. Moreover, the absence of significance in the interaction between all three variables means that our sample does not contain any small opaque subset for which a more general finding does not hold. In other words, the non-significance of these two interactions proves the generalizability of our sample.

Until now, we have considered degemination in the light of absolute duration, as has been done by Martens and Quene (1994) and Jacobs et al. (to appear). We will now proceed to a similar analysis of variance, with the same independent variables, but now with relative duration as dependent variable. Parhaps, if the relative durations remains more or less the same, the absolute differences should not be seen as a result of degemination, but more as a result of different speech rates between words with single and words with double consonants.

The mean relative durations are given in Table 3.2. Each value is the result of the consonant's absolute duration divided by the absolute duration of the preceding vowel. They should be read as follows: the length of a single consonant is 0.949 times the length of the preciding vowel (i.e. the consonant is 5.1% shorter the vowel), the length of a double consonant is 1.312 times the length of the preceding vowel (i.e. double consonants are 31.2% longer than the preceding vowel). In Table 3.2, the difference between the two ratio is relative as well: the relative duration of double consonants is 38% higher than the relative duration of single consonants.

The analysis of variance for the relative duration showed results that are similar to the results of the absolute durations. Once again, there is a significant main effect of number of consonants ($F(1, 2219) = 226, p < .001, \omega^2 = .07$) and a significant interaction between number of consonants and manner of articulation ($F(4, 2219) = 5.6, p < .001, \omega^2 = .01$). The interaction between number of consonants and geographical region was not significant ($F(3, 2219) = 1.0, p = .39$), neither was the interaction between number of consonants, manner of articulation and geographical region all together ($F(12, 2219) = 0.9, p = .60$). Once again, to interpret the significant interaction between manner of articulation and number of consonants, the analysis was split per manner of articulation as well. These statistics are given in the rightmost column of Table 3.2.

So, the results of the statistical analysis for absolute duration are the same as those of the

Manner	Single		Double		Diff.	Statistics
Plosive	0.949	$(N = 262)$	1.312	$(N = 201)$	+38%	$F(1, 455) = 61, p < .001$
Fricative	0.929	$(N = 393)$	1.130	$(N = 352)$	+22%	$F(1, 737) = 42, p < .001$
Nasal	0.522	$(N = 182)$	0.810	$(N = 171)$	+55%	$F(1, 345) = 209, p < .001$
Liquid	0.484	$(N = 175)$	0.623	$(N = 179)$	+29%	$F(1, 346) = 18, p < .001$
Glide	0.576	$(N = 180)$	0.822	$(N = 164)$	+43%	$F(1, 336) = 80, p < .001$

Table 3.2: Mean relative durations of the focus consonants, all given in milliseconds.

analysis for relative duration. Absolute differences in milliseconds between single and double consonants thus cannot be explained by vowel length: if both relative and absolute duration are higher for double consonants than for single consonants, the vowel remains (more or less) the same. It seems that the preceding vowels are not influencing the focus consonants of our experiment. Speakers make double consonants longer than single consonants, without compensating for it in the preceding vowel.

Before we try to interpret these results, we will first investigate the differences between single intervocalic consonants and lexical ambisyllabic consonants. In Section 3.3, we will proceed to an interpretation of both the above-mentioned results, as well as the results that will follow below.

3.2.2 Ambisyllabicity

The 47 participants have also pronounced word pairs that containted either a 'normal' single intervocalic consonant (which was an onset consonant) or an ambisyllabic intervocalic consonant. We measured the lengths of these consonants in order to see whether the underlying structure of these consonants could possibly effect the surface duration of these consonants. The mean absolute durations are given in Table 3.3. Since these word pairs involved different vowels before the focus consonants (i.e. /a/ for *kapen*, but /ɑ/ for *kappen*), and as such, different vowel durations are to be expected, no relative consonant durations were statistically analyzed for these minimal pairs.

As expected by looking at Table 3.3, the analysis of variance, with absolute duration as independent variable and number of consonants, manner of articulation and geographical region as dependent variables showed no significant main effect of number of consonants ($F(1, 436) =$

Manner	Single		Double		Diff.
Plosives	101 ms.	($N = 136$)	101 ms.	($N = 139$)	0 ms.
Nasals	76 ms.	($N = 47$)	77 ms.	($N = 45$)	1 ms.
Liquids	49 ms.	($N = 47$)	51 ms.	($N = 46$)	2 ms.
Fricatives (Jacobs et al., to appear)	92 ms.		97 ms.		5 ms.

Table 3.3: Mean absolute durations of the focus consonants, all given in milliseconds.

$0.2, p = .68$). None of the possible interactions reached significance either: neither between number of consonants and manner of articulation ($F(2, 436) = 0.3, p = .77$), nor between number of consonants and geographical region ($F(3, 436) = 1.3, p = .29$), and not even between all three variables ($F(6, 436) = 1.4, p = .21$). Other variables did reach significance (e.g. a main effect manner of articulation), but these variables did not test the difference between an onset or an ambisyllabic consonant, hence their statistical result is not relevant to our research question.

Since none of the above mentioned variables and interactions reached significance, we can confirm that, at least at the surface representation, there is no difference between onset consonants and ambisyllabic consonants. In the next section, we will briefly discuss these results in the light of what we have seen in the previous chapter.

3.3 Discussion

In Chapter 2.2, we have seen that Dutch is assumed to have a process of Degemination. Current literature states that either one of the two segments is completely deleted (Booij, 1995; Gussenhoven & Jacobs, 2013), or that two identical consonants would lead to ambisyllabic structures (Gussenhoven, 1986b). In Chapter 2.1, we concluded that intervocalic consonants are only onset consonants after a tense vowel, but ambisyllabic after a lax vowel, although their surface duration should not differ (Jongman, 1998; Van der Hulst, 1984, 1985). Regardless of the actual process that is triggers (i.e. either degemination or ambisyllabification), the result is that the duration of two identical consonants should be reduced to the duration of a single consonant.

The results of our production experiment thus are not compatible with the theories described in Chapter 2. The segments that should have equal durations (the degemination word pairs) differ significantly, while segments that have different underlying structures (the ambisyllabic word pairs) have statistically equal durations. This result makes us wonder whether the assumed underlying and surface representations are valid. If we were to assume that degemination would lead to a single onset consonant, how could the differences between the degemination pairs be explained? The phonetic device receives in both items of the pairs the exact same representation, while they are realized with significant differences. On the other hand, if a sequence of identical consonants would lead to ambisyllabic consonants, why is there a duration opposition between single and ambisyllabic consonants in the degemination word pairs of Section 3.2.1, but not in the ambisyllabic word pairs of Section 3.2.2?

In short, the results we presented in this chapter conflict with existing theories. However, as has been shown by Te Riele et al. (1997) and Jacobs et al. (to appear), some differences between consonants, even if these differences are significant, might by small enough to not be perceived by native speaker of this language. The results of this chapter are thus to be confirmed by a perception experiment. The next chapter, Chapter 4, will report on this experiment. Only after this confirmation, we can thoroughly investigate the validity of the current theories and verify if they are ale to explain the above mentioned results.

Chapter 4. Perception experiment

The conclusions of the production experiment of Chapter 3 were not quite compatible with the theories described in Chapter 2. Recall from Table 3.1, repeated below as Table 4.1, that the mean difference between single and double consonants was always at least 17 ms (for liquids), and up to 34 ms for fricatives. However, although this difference was significant, and thus double consonants are realized truly longer than single ones, it might still be the case that participants do not perceive this difference. For instance, Huggins (1972) and Klatt and Cooper (1975) argue that durational differences less than 20-25 milliseconds (i.e. differences of about 20%; Klatt, 1976) are not perceptible for native speakers of a language.

This difference, in the literature referred to as the *just noticeable difference*, is crucial in the perception of minimal pairs. In the perception experiment of Te Riele et al. (1997), the same minimal pairs as in Martens and Quene (1994) were used. It is not reported whether the exact same recordings were used or if new recordings were made, but the fact that the mean difference between the two items of the minimal pairs was 9 milliseconds in Martens and Quene (1994), while no differences were perceived by the participants of Te Riele et al. (1997), confirms the

Manner	Single		Double		Diff.
Plosive	115 ms.	$(N = 262)$	145 ms.	$(N = 202)$	30 ms.
Fricative	115 ms.	$(N = 393)$	149 ms.	$(N = 352)$	34 ms.
Nasal	77 ms.	$(N = 182)$	99 ms.	$(N = 171)$	22 ms.
Liquid	64 ms.	$(N = 175)$	81 ms.	$(N = 179)$	17 ms.
Glide	78 ms.	$(N = 180)$	99 ms.	$(N = 164)$	21 ms.

Table 4.1: Mean absolute durations of the focus consonants in degemination word pairs, all given in milliseconds.

hypothesis of the *just noticeable difference*. Jacobs et al. (to appear) use the *just noticeable difference* as well, and show that native speakers of Dutch cannot hear a difference between two items of a minimal pair if the difference between these items is less than 20-25 milliseconds, and that when this difference is higher, in particular fricative pairs are way better identified.

In the light of this *just noticeable difference*, we might ask if the results in Table 4.1 are really perceived as such by native speakers of Dutch. In particular the nasals, liquids and glides show a mean difference of about these 20-25 milliseconds. For these consonants, it might be the case that the difference is just low enough to not be perceived, which would suggest that listeners do perceive the words as if degemination was actually complete. The incapability of distinguishing words with such a difference could mean that, after all, the theories described in Chapter 2 are valid from a perception point of view. Based on the means displayed in Table 4.1, we might expect that this could be the case for nasals, liquids and glides, but not for plosives and fricatives, since these two groups of consonants clearly exceed the *just noticeable difference* of 20-25 milliseconds.

This chapter reports on the experiment that was set up in order to test the robustness of the production differences. Section 4.1 will outline our methodology, Section 4.2 will report on the outcome of the experiment, and finally, Section 4.3 is dedicated to a brief discussion of the results.

4.1 Methodology

The methodology of the perception is based, as was the case with the production experiment, on previous experiments. As discussed in Chapter 2.3, two other perception studies can be considered as predecessors of the current experiment. We will use the strong parts of these experiments, but we will leave out the tasks of which we believe they are unnecessary for this study.

For instance, recall the experiment of Te Riele et al. (1997), which consisted of three tasks that searched for the acoustic cues allowing a listener to identify the correct item of a minimal pair. The first two tasks, in which the fragments were cut into half (either up to including the vowel preceding the focus consonant or the focus consonant itself), showed that there were no acoustic cues present in either the focus consonant or the preceding vowel. In Jacobs et al. (to appear), the first two of three tasks were also dedicated at finding possible acoustic cues, by asking participants to focus on either vocalic or consonantal differences. In both studies, no effect of the preceding vowel has been found, and neither did we find vocalic influences in our production experiment. We therefore decided to leave tasks similar to the first two tasks in the above mentioned studies out of our experiment.

What we did reuse from these two studies was a task similar to the third task of both experiments. In this type of task, listeners were confronted with the entire recording of one item of a minimal pair, and they had to identify this item. Te Riele et al. (1997) let the participants listen to the entire carrier phrase, while Jacobs et al. (to appear) played only the focus words. To reduce possible distracting effects, as well as to reduce the overall length of the perception experiment, we only let the focus words hear, without the carrier phrase. In Section 4.1.2 we will come back to the stimuli, we will first start by a description of the participants. The end of this section is dedicated to a description of the procedure and statistical analysis.

4.1.1 Participants

For this experiment, we asked students from the Radboud University in Nijmegen to participate. Initially, a group of 12 Bachelor's students, of which about half was male, other half female, volunteered to participate in the experiment. During the experiment, the experimental environment (the online WebExp environment of the Radboud University[1]), crashed fatally and therefore, half of the data was lost. The reason of the crash was solved and carefully tested once again, and another group of 12 students was found to participate in the experiment. Some of these students also experienced a crashing environment, but this time it considered only the last few fragments of the experiment, so if we consider the fragments they could not play as missing, we still have enough data to compensate. Among the students of the second group figured a few sixth-graders from a secondary school, but since these students were also following a course at the Radboud University, we still wanted to include them in the analysis.

The same procedure described below was also applied with the first group, but since the participants only completed half of the experiment, and after fixing the crash small changes in the stimuli ordering were applied, we did not want to mix these results with those of the second group of participants. Nonetheless, more or less equal percentages and significance values were

[1] `http://www.ru-webexperimenten.nl.`

obtained for both groups. In the remainder of this Chapter, we only report on the second group of student.

4.1.2 Stimuli

The stimuli that we used for this experiment were all taken from the production experiment. The selection of fragments consisted of two steps. First, we only used audio fragments from minimal pairs of which the only difference was the focus consonant. So, items like *BH-koper* (single plosive /k/) versus *hooihaakkoper* (double plosive /k/), which would only be useful after segment manipulation, were excluded from this experiment. The remaining 22 pairs were used for this experiment. For each pair, we selected at least two speakers per geographical region. The first speaker was the one that produced a difference between single and double consonant that was the closest to the mean difference for this pair in this region. The other speaker that was selected was one that produced the smallest difference between the two words. For the selection of this second speaker, a speaker for which the double consonant was 3 ms longer than the single consonant was preferred over a speaker whose double consonant was 10 ms shorter than his single consonant. In the case that the mean difference between single and double consonants for a specific pair in a specific region was almost zero, a speaker that produced a large difference between the two (approx. 40 ms) was selected.

As such, we always had one speaker with a difference close to zero, and one with a larger difference between the two items. The reason for balancing the stimuli in this way, is that we want to make sure that duration is the only cue that is used. When there is a durational difference present, we expect participants to correctly identify an item based on this difference. If participants are also capable of correctly identifying an item when there is no durational difference, if might be possible that there are other acoustic cues present – even though previous studies conclude otherwise.

Inspection of the acoustic signal showed that in the recordings made in Amsterdam, some of the higher frequencies were not well captured. Although this was not problematic in the production experiment, where based on the surrounding segments all consonant lengths could still be correctly measured, these fragments could not be used in the perception experiment. As such, we only kept the fragments from Uden, Zierikzee and Zwolle. This led to a total number of (22 minimal pairs x 3 regions x 2 speakers per region x 2 items per pair =) 264 test items.

These items were all randomized in such way that participants of the experiment would never have to identify an item of the same pair in a row. To control for effects of the list, a second version of the experiment was created, in which the order of the fragments was reversed.

4.1.3 Procedure and Analysis

As stated above, the experiment was created within the online WebExp environment of the Radboud University. Half of the participants completed version A, the version with the randomized order, the other half completed version B, which was the reverse order of version A. Each fragment was played once, and contained either a word with a single focus consonant or a word with a double focus consonant. After playing the focus word, the participants had 10 seconds to indicate which word of the minimal pair they heard. There were always two options, the first option was the word with a single consonant, the second option was the word with the double consonant. Participants had to indicate the correct answer by means of pressing either 1 or 2 on their keyboard, corresponding to the word they believed they heard. Before the experiment started, the participants were presented two examples, in which not only the audio fragment, but also the orthographic representation of the audio fragment was given (i.e. *Je hoort nu ...* 'You are now hearing'). In this way, the participants could get used to the experimental environment.

At the end of the experiment, the digital environment produced a result file containing the question number, the given answer and the correct answer. This data allowed us to calculate percentages of correct responses. We separated our data set in two groups, based on the durational difference between the focus consonants. The first group contained all 132 fragments that were selected based on mean differences between single and double consonants. The second group contained the fragments that were selected based on the absence of such a difference, this group consisted of 106 fragments. A third group containing the remaining 26 items that were selected because the mean difference was already close to zero was ignored. Once again, since the mean differences, as we find them in Table 4.1, are close to or larger than the *just noticeable difference* of 20-25 ms, we expect that participants are able to correctly identify the words of the first group, but not in the second group.

The participants were confronted with only two options, hence they had a chance of 50% of giving the correct answer. To test if the percentage of correct responses is really higher (i.e. significantly higher) that chance level, we use a one-sample binomial test. This test computes the probability of obtaining our percentages if the chance of giving a correct answer were 50% indeed. If this probability is less than $p = .05$, there is a 95% chance that the obtained responses are *not* by chance. So, if the one-sample binomial test gives a significant result ($p < .05$), we may conclude that participants can really distinguish the items of a minimal pair.

4.2 Results

We start this section by looking at the percentages of correct responses for the first group of fragments. This group contained all minimal pairs of speakers that produced a difference between single and double consonants that is close to the mean difference. In other words, this group of fragments can be used to test whether the mean differences we found in the production experiment are perceivable by native speakers of Dutch. From the 132 fragments that have been played, we obtained 1357 valid responses. Table 4.2 reports for each manner of articulation the mean difference between single and double consonants of those fragments that were used in the perception experiment, followed by the percentage of correct identifications. The last column of this table reports on the chance that these percentages occur by chance. Since we selected for each minimal pair and for each geographical region the one speaker with a difference between single and double consonants that was as close to the mean of this pair in this region as possible, there is a subtle difference between the mean differences in Table 4.2 and the differences observed in the production experiment (cf. Table 4.1) Nonetheless, the selected fragments still represent the average durations.

Manner of articulation	Mean difference	Correct Identifications Single	Double	Total	N	Significance
Plosives	22 ms.	73%	30%	52%	$N = 311$	$p = .50$
Fricatives	31 ms.	82%	38%	60%	$N = 429$	$p < .001$
Nasals	27 ms.	82%	47%	64%	$N = 176$	$p < .001$
Liquids	16 ms.	70%	55%	63%	$N = 251$	$p < .001$
Glides	30 ms.	80%	85%	83%	$N = 190$	$p < .001$

Table 4.2: Percentages of correct identifications for the first group of fragments (those with an average difference between single and double focus consonants)

As we can see in Table 4.2, plosives behave different than other consonants. Plosives have an identification score of 52%, which is statistically comparable to chance level ($p = .50$). Although 73% of the single plosives are correctly identified, 70% of the double plosives were also identified as single ones, hence we have to conclude that listeners cannot perceive the differences between the fragments. Other consonants have higher identification rates. Although single fricatives, nasals and liquids (70% – 82%) are still way better identified than their double counterparts (38% – 55%), the overall percentage of correct identifications is 60% – 64% for these three manners of articulation, which, based on the large sample size, is significantly above chance level.

Within the first four manners of articulation in Table 4.2, single consonants are better recognized than double ones. This is not the case for glides: both single and double glides have identification sores of 80% – 85%, and obviously their overall identification score is far above chance level.

From the first group of fragments, we can already conclude that, even when there is a duration opposition between single and double plosives, they are perceived as degeminated. For the other manners of articulation, it might still be the case that there are other acoustic cues present in the segment that allow for a correct identification. To test whether duration is the only cue, we also calculated the mean percentage of correct responses for our second group of fragments, in which the difference between single and double consonants was (almost) zero. The results are given in Table 4.3.

The 106 fragments led to a total of 1068 valid answers for this group of fragments. Once

Manner of articulation	Mean difference	Correct Identifications Single	Double	Total	N	Significance
Plosives	4 ms.	70%	34%	52%	$N = 267$	$p = .54$
Fricatives	0 ms.	78%	26%	53%	$N = 336$	$p = .30$
Nasals	0 ms.	76%	38%	57%	$N = 181$	$p = .053$
Liquids	4 ms.	76%	29%	53%	$N = 105$	$p = .56$
Glides	2 ms.	87%	54%	71%	$N = 179$	$p < .001$

Table 4.3: Percentages of correct identifications for the second group of fragments (those without a difference between single and double focus consonants)

again, the mean difference between the selected single and double consonants is given in the second column of Table 4.3. We observe more or less equal identification scores for the single plosives as in 4.2, but the identification scores of double plosives is now much lower: only double glides have a score of 54%, all other consonants have scores between 29% and 38%. The overall percentages are statistically not higher than chance level, so we can come to the conclusion that for these consonants, degemination is not only complete in terms of absolute duration, but also in terms of perception.

Glides form a group that behaves differently. Although the identification of double consonants is merely above chance level (statistically, the difference will not be significant), the high percentage of correct identifications for single glides is high enough to ensure an overall percentage of 71%. Somehow, there must be an acoustic cue present in the signal that allows the listeners to correctly identify single or double glides. Since this was not absolute duration, there must have been something else present in the signal that helped the listeners come to their judgment.

4.3 Discussion

In this perception experiment, we observed three different behaviors: glides are always well identified, plosive not at all, and all other consonants only if there is a length opposition between the focus consonants. This observation is surprising, given the fact that the differences between single and double consonants in the production experiment were all significant, and were, on average, around the *just noticeable difference*. Why are the differences in some manners of articulation better perceived that with others?

First of all, it is probable that the different behavior of glides has nothing to do with the consonantal duration, but more with the e.g. vowel that precedes them. In Dutch, mid and high vowels that occur in open syllables, are often followed by an inserted glide. (Booij, 1995; Rubach, 2002). If so, then front vowels (such as /e/) are followed by a front glide (i.e. /j/), and back vowels (such as /o/) are followed by a back glide (i.e. /w/). If degemination would be applied, there would still be a contrast possible in a pair such as *strojongen* 'straw + boy' versus *stroojjongen* 'scatter.1SG + boy', in the sense that the first could be pronounced as [strowjɔŋən] and the latter as [strojɔŋən]. This glide insertion could be the reason why the words of the glide minimal pairs have a higher identification rate even when there are no durational differences.

It would have been better to include a minimal in which the preceding vowel and the focus consonant were either both front of both back, but such a pair was not found. We did include *macho-waarzegger* versus *showwaarzegger* in the production experiment, but this pair could not be used in the perception experiment. A future study in which the focus consonants of this pair are changed or manipulated, and reaction times are measured, might tell us whether degemination could be complete or not. For now, we do not have enough information to say whether glides are degeminated or not. The possible absence of degemination is in line with previous studies: Booij (1995) formulated degemination in such way they do not involve glides, and Jacobs et al. (to appear) did not observe degemination for glides either.

All other consonants, that is, plosives, fricatives, nasals and liquids, have identification scores that are around chance level when there is no durational difference between the focus consonants in the minimal pairs. Fricatives, nasals ans liquids have higher identification scores when the duration of the focus consonant changes. So for these three groups of consonants, consonantal length determines the perception. Double plosives that are actually longer than single plosives are not recognized as such. One possible explanation for this difference could be that the *just noticeable difference* is not the same for all manners of articulation. It looks as if for fricatives, nasals and liquids, a difference can be rather small and still be noticed by the listener, but for plosives this difference would have to be higher. Another possible explanation could be the expectation of the listener. Listeners might have the idea that fricatives, nasals and liquids are just one continuous sound, while plosives consist of building up tension in the mouth, followed by a clear release. It could have been the case that listeners expected two releases for double plosives, while in fact the lengthening was only concentrated in the accumulation of tension, and not in the release. As a result, the absence of a second release could have triggered the misperception of double plosives.

The possibility of different *just noticeable differences* is confirmed by splitting the first group of fragments into two new groups, in the same way Jacobs et al. (to appear) did. One group contains all word pairs in which the difference between single and double consonants was less than 20 milliseconds (i.e; less than the *just noticeable difference*); the other group contains fragments with a larger difference between these consonants. The percentages of correct identifications for these subgroups is given in Table 4.4. If the *just noticeable difference* would be 20 milliseconds for all manners of articulation, we would expect non-significant results for word pairs in which the difference between single and double plosives is less than these 20 ms. In word pairs for which double plosives are more than 20 ms. longer than single plosives, we would expect percentages that are always significantly higher than chance level (50%). Table 4.4 shows that the percentages of correct identification of plosives is never above chance level, not even when we only examine the word pairs for which the difference between single and double plosives was larger than 20 ms. The *just noticeable difference* for plosives thus is higher than 20 ms. On the other hand, fricatives and liquids are still correctly perceived when the difference between single and double consonants is less than 20 ms. For these two groups, the *just noticeable difference* might be lower than 20 ms. For nasals, there were to fewer responses ($N = 24$), hence it is difficult to say whether the absence of significance is informative.

Regardless of the reason why the difference between plosives is not perceived, we can conclude that double plosives are always perceived as single consonants. So, perceptually, they are degeminated, while fricatives, nasals and liquids are not. This corresponds with the results found by Jacobs et al. (to appear), who also found that differences between single and double fricatives can be perceived, but differences between single and double plosives not.

Now that we have presented our production and perception experiments, we can adequately provide an answer to the second of our research questions. In the next chapter, we will first briefly recapitulate these questions, and answer the questions concerning the domain of degemination. Afterwards, we will see how our results affect the current theories concerning degemination and ambisyllabicity.

Manner of	Difference $<$ 20 ms.			Difference $\geq$ 20 ms.		
articulation	Correct	N	Significance	Correct	N	Significance
Plosives	48%	$N = 143$	$p = 0.62$	56%	$N = 168$	$p = 0.14$
Fricatives	61%	$N = 104$	$p = 0.039$	60%	$N = 325$	$p < .001$
Nasals	52%	$N = 24$	$p = 0.54$	65%	$N = 152$	$p < .001$
Liquids	53%	$N = 172$	$p = 0.027$	71%	$N = 79$	$p < .001$
Glides	75%	$N = 20$	$p = 0.041$	84%	$N = 170$	$p < .001$

Table 4.4: Percentages of correct identifications for the first group of fragments, split according to the *just noticeable difference*

Chapter 5. Phonological implications

The previous two chapters discussed a production and a perception experiment, which were designed in order to answer our three research questions which we stated at the end of Chapter 2. In this chapter, we will revisit these questions and try to find appropriate answers to these questions. As we have already stated in the previous two chapters, the results we obtained in our experiments did not match our expectations based on current phonological literature. In this chapter, we will combine the theoretical issues (Chapter 2) and experimental results (Chapters 3 and 4) and find out how we can harmonize them both. We will discuss two possible solutions, and verify if they could match with our experimental results.

Before we dive into these theoretical explorations, let's first recapitulate the research questions we proposed at the end of Chapter 2. First of all, the exact working of degemination was unclear: what will be the change that degemination causes to the phonological representation? Gussenhoven (1986b) proposes an ambisyllabic configuration, Booij (1995) and Gussenhoven and Jacobs (2013) propose simple onset consonants. Which configuration should be favored?

Second, which consonants are subject to degemination? Are there any exceptions to degemination, such as fricatives (Jacobs et al., to appear) or glides (Booij, 1995)? And are the results for one speaker (Martens & Quene, 1994) or a group of speakers from the south-western part of the Netherlands (Jacobs et al., to appear) representative for the entire Dutch speaking comunity in the Netherlands?

And finally, if some consonants indeed appear to retain their length, and thus function as long consonants, what are the consequences for ambisyllabicity? In other Germanic languages such as English, German and Danish, ambisyllabicity has been refuted (Jensen, 2000). Are there still enough reasons to maintain ambisyllabicity? Could it be possible to abolish ambisyllabicity for Dutch as well, or is it still valid to distinguish ambisyllabic from single onset consonants?

The second of these question has been answered by our experiments: we measured the consonant durations and found that none of the consonants was completely degeminated. The difference was at least 17 ms. (for liquids) and up to 34 ms for fricatives. In the perception experiment, it was confirmed that speakers of Dutch are able to hear a difference between single and double consonants, except for plosives. For plosives, we thus can conclude that although we measured a difference that is even larger that the *just noticeable difference* of 20-25 ms. (Klatt, 1976; Klatt & Cooper, 1975), speakers still do not perceive this difference. So, plosives are perceptually completely degeminated, while fricatives, nasals and liquids are not.

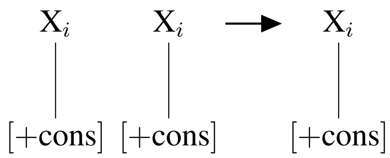
Glides form another group of exceptions: when we used minimal pairs that had a difference between single and double consonants, 83% of the identifications were correct. Within the pairs that had no duration difference between single and double consonants, still 71% of the words was correctly identified, a percentage that was significantly above chance level. So, for glides, there must have been some other acoustic cue(s) (e.g. vowel quality, glide insertion or diphthongization) that helped the participants making the correct identification. It is highly probable that this cue is present in the pairs that had a difference of on average 21 ms. between single and double glides as well, and as such, it might even be the case that participants identified the words based on this cue instead of the durational difference. For glides, it thus is impossible to say whether degemination occurs or not.

So, to answer the research question: plosives are degeminated, fricatives, nasals and liquids are not, and for glides there are other cues present that makes it impossible to estimate the effect of consonantal duration. This result corresponds more or less with Jacobs et al. (to appear), who also found degemination for plosives and glides, but not for fricatives and liquids. This means that their result, which was found in the Nijmegen region, can be extrapolated to the entire Dutch speaking community, since there were no significant interactions of the four geographical regions on the differences between single and double consonants.

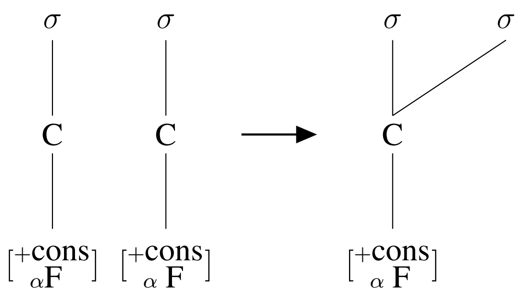
The other two research questions concern the exact working of degemination and the ambisyllabic status of consonants. The following section will discuss how the results of our experiments conflict with the current literature on degemination and ambisyllabicity. We then will dive into two possible solutions to overcome this conflict and answer the first and the third research question.

5.1 Conflicting results in the light of current theory

In Section 2.2.3, we presented two possible outcomes of degemination. One possibility, the one that occurs in most accounts, is the one presented in (44) and (45). For the sake of readability, (45) is repeated here in (49). The other possible outcome of degemination was a resyllabicifation leading to a configuration similar to ambisyllabic consonants. This outcome was presented in (46), repeated here in (50).



(49) DEGEMINATION: Domain: obligatory within prosodic words, optional in other domains



(50) DEGEMINATION:

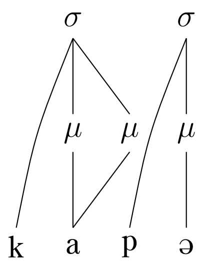
The point we want to make clear is that with the phonological proposals as we have presented in Chapter 2, neither of these two degemination rules can be supported by our data. (49) would predict that the two consequtive underlying fricatives in *veeggebied* /vex.xəbid/ are changed into the same configuration as *veegebied* /ve.xəbid/, while the corresponding output is not the same. On average, double fricatives were 34 ms. longer than their single counterparts, and in the perception experiment this differences was large enough to be perceived by listeners. Hence, we have to refute (49).

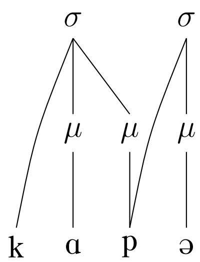
When we hold on to an ambisyllabic configuration for intervocalic consonants that follow a lax vowel (e.g. as in *kappen*), rule (50) has to be refuted as well. Although this rule would predict different representations for *veegebied* and *veeggebied*, which corresponds to our results, there is a conflict with the results of our ambisyllabic word pairs. If we were to assume (50), *veegebied* and *kapen* would both have the same representation (single onset consonant), and *veeggebied* and *kappen* would both have the same representation (ambisyllabic configuration). However, *veegebied* and *veeggebied* have different consonant lengths, while *kapen* and *kappen* have the same consonantal durations. So, the outcome of degemination cannot be an ambisyllabic configuration if this configuration is also used for intervocalic consonants preceded by a lax vowel.

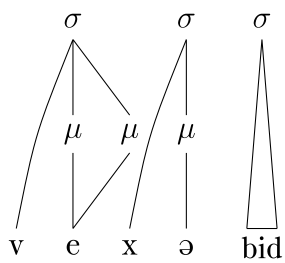
In short, there is a conflict between the degemination and ambisyllabicity. In order to have a theory that is supported by our data, we either have to modify the application of degemination, or to change the status of ambisyllabic consonants. In the remainder of this chapter, we will explore these two options and propose the answers to our research questions.

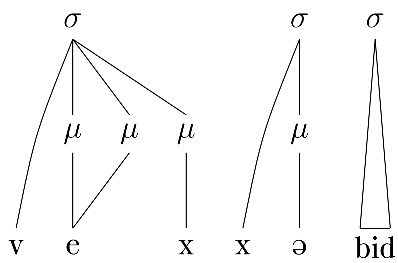
5.2 Fake geminates

One option to account for the mismatch between theory and experimental results is to say that degemination only applies for plosives. If that were true, and fricatives, nasals and liquids would retain the representation of (49) before application of the rule, which is that of a fake geminate. Fake geminates, just like true geminates, are long consonants, except that in the underlying representation, there is no linking between the two segments. If we accept this solution, Dutch would distinguish *veegebied* from *veeggebied* by either having one or two segments, and the length distinction we found in Chapter 3 could be explained by this structural difference. We than could have a three-way distinction between single consonants as in (51a) and (52a), ambi-

(51) a.


b.


(52) a.


b.


syllabic consonants as in (51b) and fake geminates as in (52b), where the first two are of similar duration and only the latter has a longer duration.

The question now is whether this three-way distinction can satisfy our research questions. We proposed two different degemination rules, one with single consonants as a result, the other with ambisyllabic consonants as a result. The solution to work with the non-application of degemination does not offer more insight in this question: the outcome of degemination could still be either of the two. Since ambisyllabic consonants are just as long as regular onset consonants, there is no reason why one should be the outcome in favor of the other. The fact that *heette* /het+tə/ 'to be called (1SG.past)' leads to a single onset and *zette* /zɛt+tə/ 'to put (1SG.past)' to an ambisyllabic configuration means that regardless of the degemination outcome we choose, an additional rule is required to obtain the other configuration. If we assume degemination to produce single onset consonants, we need a rule that transforms all intervocalic consonants preceded by a lax vowel into ambisyllabic ones. If we assume degemination to produce ambisyllabic consonants, we need a deambisyllabicifation rule to obtain single consonants after tense vowels. Since the original idea of Van der Hulst (1984, 1985) was that ambisyllabicity is required to make the preceding rhyme consist of two elements, it is in line with this idea to assume degemination to produce single onset consonants, although there is no reason to assume otherwise.

Assuming fake geminates to explain our data that involves the same consonants across word-boundaries, has also an influence word-internally. According to our data, plosives are degeminated across word-boundaries, and we have seen in Chapter 2 that degemination also occurs in words such as *heette* (47) and *zette* (48). If degemination does not occur across word-boundaries for all other consonants, it should not word-internally either. However, we lack the data to support this assumption, but we highly doubt whether fake geminates (and thus longer consonants) should occur word-internally as well.

If we use the non-application of degemination to explain our results, we not only are unable to provide a satisfying account for degemination, but we also cannot make a clear judgment on the validity of ambisyllabicity. We can maintain it within the phonology of Dutch, but there is no clear reason why we should. In Section 2.1, we described the arguments that were given in favor of ambisyllabicity, among which we considered the binarity of the syllable, but we believe that these arguments are not strong enough to maintain this structure. In the next section, we will defend this claim, for now we just observe that our experiments do not provide evidence either in favor of or against ambisyllabicity.

Besides the inability to give insight in either degemination or ambisyllabicity, explaining our experimental results by means of fake geminates is dissatisfying in another way as well. First of all, it feels counter-intuitive to use the representation of fake geminates for consonants that are realized as long ones, while the structure for geminates (thus for long consonants) is used for ambisyllabic consonants with the same duration as short single consonants. It is also ironic that ambisyllabicity is required to ensure the binarity of the rhyme, but if the consequence of retaining ambisyllabicity is a fake geminate structure as in (52b), we still do not have a binary rhyme word-internally.

Furthermore, the binary option of either application or omission of degemination implies that either there should be (more or less) identical consonant durations, or there should be a clear length opposition between two words of a similar pair. Using degemination as a rule leaves very little room for degemination as a gradual phenomenon, while Martens and Quene (1994) actually concluded that it should be so. Our results show that the difference between single and double consonants is gradual indeed, as is shown in Figure 5.1. This figure shows a histogram of the differences between focus consonants of a minimal pair. Although there are two peaks at both around zero and round 30 milliseconds, the frequency of minimal pairs with a difference between zero and 30 milliseconds is also very high. This means that there have been many minimal pairs in which degemination was neither 100% absent nor 100% complete, *ergo* degemination is a gradual phenomenon

The only way to allow for gradual degemination is to leave all fake geminates in the representation that is transmitted to the phonetic device, and let this device, determine whether degemination should be applied completely, partially or not at all. However, the problem with postponing degemination to the phonetic device is that, as we have stated above, after degemination one other rule has to follow that allows to distinguish ambisyllabic and single consonants (resp. *zette* and *heette*). Although the absence of such a rule would not affect the actual duration, and hence should not raise any troubles for the phonetic device, it would seem arbitrary to require a distinction between single and ambisyllabic consonants when they occur in the uninflected verbs, but to allow a confusion between them after degemination.

Finally, a fake geminate representation means that the two elements are not connected. We believe though, that double consonants should at least be connected in some way. Since double consonants are not twice as long as single consonant, and thus not realizes individually, there must at least be some degree of connection between the two segments.

So, the straightforward solution to account for our experimental data, which is the non-application of degemination, and as such, relying on fake geminates, turns out not to be that appropriate after all. Although it provides a structural difference between degeminated consonants (either single or ambisyllabic) and long consonants (fake geminates), it has no explanatory value at all. It would only dissolve the apparent contradiction between current theory and our experimental results, but it actually makes the process of degemination more opaque. The resulting structure could either be a simple onset or an ambisyllabic consonant, and as such it makes it difficult to defend ambisyllabicity. If any, it makes it even harder to retain the notion of lexical ambisyllabicity, since its presence (and thus its complementary distribution with single consonants) makes it impossible to account for the graduality of degemination.

We therefore propose another, more radical solution to the contradiction of our results with

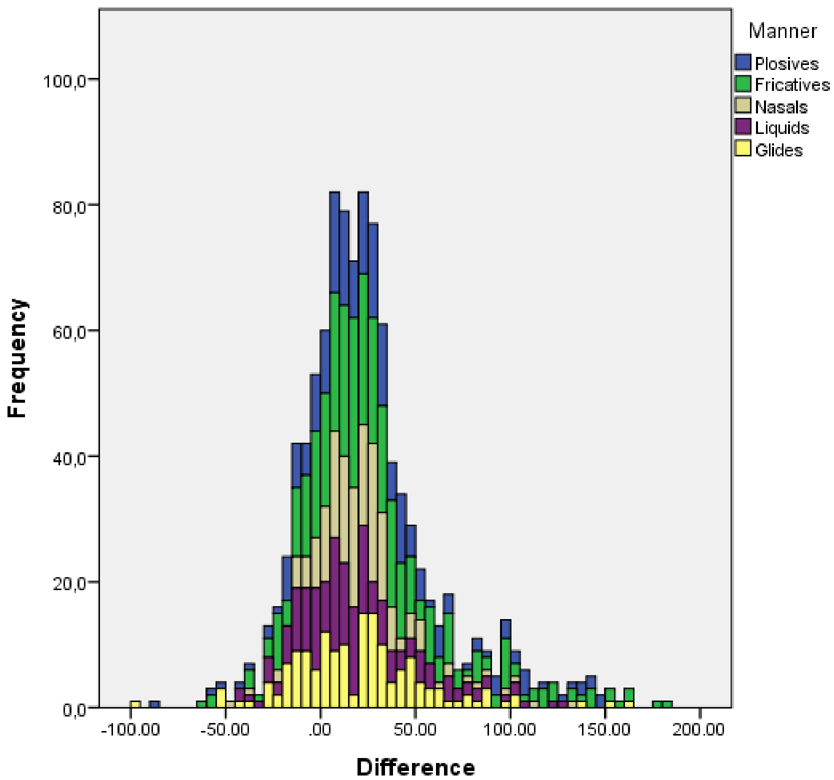
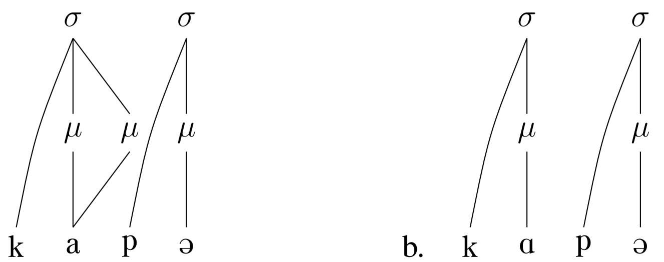


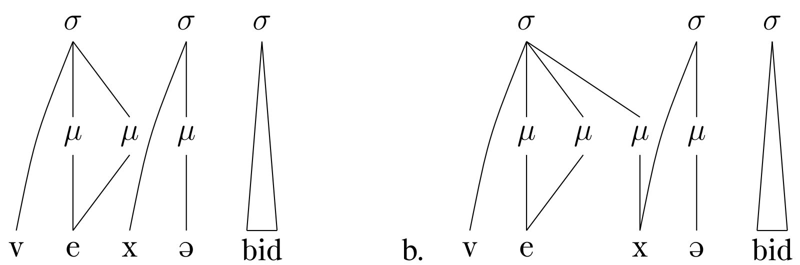
Figure 5.1: Histogram of the differences in milliseconds between single and double consonants in the production experiment.

the existing theory. In the next section, we will explain how a theory without ambisyllabicity can both account for our results and can account for the graduality of degemination. As such, we hope to find more satisfying answers to our research questions.

5.3 Abolition of ambisyllabicity

In order to explain our results from the experiments, we either have to assume the non-application of degemination (and thus fake geminates), or the application of (50), which leads to an ambisyllabic configuration. The other degemination rule cannot be applied since that would lead to the wrong prediction that *veegebied* and *veeggebied* would have the same intervocalic consonant. The problem with assuming an ambisyllabic configuration after degemination was the fact that word-internally, there is no durational contrast between single and ambisyllabic consonants, while there is one between the two words we just mentioned. Since the only alternative, assuming the non-application of degemination, is not that satisfying at all, we will explore whether the abolition of ambisyllabicity can provide better answers. If we represent all consonants that currently are considered ambisyllabic (i.e. in *kappen* and *zette*) as simple onset consonants, and accept the ambisyllabic configuration as a result for degemination, we obtain a two-way distinction instead of a three-way distinction that still covers our results. On the one hand, we have single onset consonants (so both *kapen* (53a), *kappen* (53b) and *veegebied* (54a)) that are all short, and on the other hand, we have ambisyllabic consonants (thus *veeggebied* (54b)) that are longer.

(53) a.


(54) a.


If we accept this solution, we can finally provide a clear answer to our first research question (i.e. the representation of degemination): degemination should be represented as proposed by Gussenhoven (1986b), so with an ambisyllabic configuration as a result. Not only our results, but also the arguments Gussenhoven proposed himself, which we discussed in Section 2.2.3 are convincing. Besides that we have a structural distinction between e.g. *veegebied* and *veeggebied*, which can explain our data, we also can now explain the graduality of degemination as well: since the result after the application of the rule is always the same, we can leave it up to the phonetic device how to deal with the configuration. With the deletion of ambisyllabicity in words like *kappen*, the only occurrence of this ambisyllabic structure is after degemination, so the phonetic device will recognize this structure as a context to optionally lengthen the consonant. *Heette*, *zette*, *bijtteentje* and *veeggebied* will thus all have the same ambisyllabic/geminate configuration, but the phonetic device can determine that the plosives in *heette*, *zette* and *bijtteentje* are always equally short to the single plosives in *kapen* and *bijteentje*.

If we were indeed to limit the ambisyllabic configuration to the outcome of degemination, we could also consider the process of degemination as a process in which two apparent fake geminates obtain a true geminate status. In Chapter 2.2, we saw that the structure of true geminates and ambisyllabic consonants is identical, and because of the length opposition we found in our experiments, calling these structures geminate structures resembles the reality better than an ambisyllabic structure. Note that in either case we want to call it an ambisyllabic structure or a geminate structure, and not ambisyllabic consonants (as we just argued against lexical ambisyllabic consonants) or true geminates. We believe that the latter is too strong: in languages with true geminates, such as Italian, there is a lexical distinction between single and geminate consonants, while in Dutch, we do not have such lexical distinctions. We only observe gemination when a word ends in a consonants and the following word starts with the same consonant (i.e. fake geminates), but we believe that allowing (derived) true geminate structures for them can explain the measurements of our experiments in a more natural way.

So far, we have answered the first research questions. The only remaining research question considers ambisyllabicity. Can we really exclude ambisyllabicity and cover the arguments that were proposed in favor of it? These arguments, which we elaborated on in Section 2.1, involve syllable structure, stress assignment and distributional observations concerning hiatuses. It will be in this order that we will discuss the validity each of the arguments.

(55) /profɛsɔr/	ONSET (31)	LAX+C (30)	SONPEAK (18)	WSP/SWP (22) / (23)	F_sRIGHT (26)
a. pro.ˈ(fɛ.sɔr)		*!		*	
b. pro.ˈ(fɛː.sɔr)		*!		*	
c. pro.ˈ(fɛs.ɔr)	*!		*	*	
☞ d. pro.ˈ(fɛs.sɔr)			*	*	
e. pro.ˈ(fɛːs.sɔr)		*!		*	
f. ˈ(proː.fɛs).(ɔr)	*!		*	*	*
g. (proː.fɛ).ˈ(sɔr)		*!			

First of all, the main argument in favor of ambisyllabicity was the binarity of the rhyme. Since short vowels (e.g. /ɑ/ in *kappen*) only take one position in the rhyme, a coda consonant would be required to ensure this binarity. Long vowels (e.g. /a/ in *kapen* do not need so, because they occupy two positions in this rhyme. Gussenhoven (2009) has shown that, based on acoustic measurements in Rietveld et al. (2004), the underlying opposition between /a/ and /ɑ/ should not be length but tenseness. /a/ should be underlyingly a tense short vowel, /ɑ/ should be underlyingly a lax short vowel. Tense vowels then are lengthened under stress, while lax vowels are not. The only exception to this are the high tense vowels, that even under stress remain short. However, tense high vowels are not necessarily followed by a coda, which is thus a violation of the binary rhyme constraint. If we deny ambisyllabicity, short vowels would lead to a violation of this binary condition as well. Since we already accept this violation for tense high vowels, why not for all lax vowels?

The second argument in favor of ambisyllabicity was stress assignment. If we deny ambisyllabicity, this has a consequence for the OT constraint LAX+C (30), which we introduced in Section 2.1.2.2. This constraint requires lax vowels to be monomoraic and to be followed by a tautosyllabic consonant. Recall from Tableau (32), here on the next page as (55), that ambisyllabicity came from the interaction of ONSET (31) and LAX+C. All candidates in which the /s/ was not an onset, which were candidate (55c) and (55f), were violating ONSET, and all candidates in which the /s/ was not a coda (i.e. (55a,b,e,g)) violate LAX+C.

Removing ambisyllabicity and turning them into single onset consonants means that LAX+C may not require lax vowels to be followed by tautosyllabic consonants. However, simply re-

(56) HIGHV-μ: High vowels are monomoraic.

(57) /pitə/	HIGHV-μ (56)	ONSET (31)	LAX+C (30)	SONPEAK (18)	WSP/SWP (22) / (23)	SYLMON (25)
☞ a. ˈ(pi.tə)					*	
b. ˈ(piː.tə)	*!					*
c. ˈ(pit.tə)				*!		*
d. ˈ(pit.ə)		*!				*

(58) /kapə/	HIGHV-μ (56)	ONSET (31)	LAX+C (30)	SONPEAK (18)	WSP/SWP (22) / (23)	SYLMON (25)
a. ˈ(ka.pə)					*!	
☞ b. ˈ(kaː.pə)						*
c. ˈ(kap.pə)				*!		*
d. ˈ(kap.ə)		*!		*		*

moving this constraint means that lax vowels would have to be lengthened in order to satisfy the stress-to-weight principle SWP (23). This principle requires all foot heads to be bimoraic. As stated before, high vowels are an exception to this bimoraicity. To remain short, they must remain monomoraic, which is obtained by the higher ranking of HIGHV-μ (56) above SONPEAK (18) and SWP. This is visualized in (57), where the high vowel of *pieten* 'fellers' remains short in candidate (57a). Without this constraint, candidate (57b), in which the vowel is lengthened, would be the output candidate. Compare this with *kapen* in (58), where no high vowel can violate HIGHV-μ; here the candidate with the long vowel (58b) is more optimal than the candidate with the short vowel (58a).

If we can prevent high vowels from lengthening, we could also prevent lax vowels from lengthening with a very similar constraint: LAXV-μ (59). Just like HIGHV-μ is violated when high vowels are bimoraic, this constraint is violated when lax vowels become long. This con-

(59) LAXV-μ: Lax vowels are monomoraic.

(60) /profɛsɔr/	ONSET (31)	LAXV-μ (59)	SONPEAK (18)	NONFIN (20)	WSP/SWP (22) / (23)
☞ a. pro.ˈ(fɛ.sɔr)					**
b. pro.ˈ(fɛː.sɔr)		*!			*
c. pro.ˈ(fɛs.ɔr)	*!		*		*
d. pro.ˈ(fɛs.sɔr)			*!		*
e. pro.ˈ(fɛːs.sɔr)		*!			*
f. ˈ(proːfɛs).(ɔr)	*!		*		*
g. (proːfɛ).ˈ(sɔr)				*!	

straint should be located in the same place asLAX+C was, as is illustrated in (60).

The output candidates of (60) are the same as presented in (55). Recall that candidates (55a,b,e,g) were violating LAX+C. With the replacement of this constraint by LAXV-μ, only candidates (60b,e) are out-ruled by this constraint, because of their long vowel. Candidate (60g), which crucially violated LAX+C because of it absence of a coda /s/ was also violating NONFIN (20) by placing main stress on the last syllable. With the replacement of LAX+C by HIGHV-μ, this violation of NONFIN is now the crucial one that outrules this candidate. Candidate (60d), which was the most optimal candidate under LAX+C, is now less harmonic than (60a), since it violates SONPEAK (18).

So, Tableau (60) shows that it is still possible to account for Dutch main stress when ambisyllabicity is excluded. All consonants that were considered ambisyllabic can just be represented as single consonants, by simply replacing LAX+C by HIGHV-μ. Where LAX+C caused onset syllables to become ambisyllabic, now SONPEAK prevents them from becoming so. This constraint, as discussed in Chapter 2.1.2.2, is violated when the first two moras of a syllable are not vocalic. In (60d), the ambisyllabic /s/ functions as second mora, and thus violates SONPEAK. In (60a), even though the second syllable [fɛ] has only one mora, this mora is vocalic and thus does not violate SONPEAK.

We have now shown that the core arguments for ambisyllabicity (i.e. the syllable structure and stress assignment) are not strong enough to maintain ambisyllabicity. The only argument in favor of it that we have not discussed yet, involves distributional observations, of which we believe they are not strong enough to retain ambisyllabicity. The observations Van der Hulst

(1985) made, include the absence of short vowels word-finally and the absence of hiatuses after short vowels.

Since both observations would mean that a syllable could not end in a short vowel, Van der Hulst (1985) suggested the already discussed binary syllable structure. However, Dutch does have some words ending in a short vowel: there are monosyllabic exclamations such as *bah!* and *joh!*, and there are loan words such as *bourgeois* /bur.ʒwɑ/ 'middle class' or *cabaret* /kabarɛ/ 'cabaret'. Word-internally, there are also indeed no hiatuses after single short vowels[1]. For instance, *hiaat* /hi.at/ 'hiatus' is a Dutch word, but /hɪ.at/ is not. After a syllable ending in the diphthong [ɛɪ], which ends in a short lax vowel, a new syllable starting with a vowel is allowed though. Requiring a binary rhyme could be one solution to prevent all other types of hiatuses, but then high vowels form an exception to this requirement. To explain the absence of this type of hiatuses, by assuming neither a binary requirement, nor ambisyllabicity, we could rely on a new constraint such as *HIATUS (61).

(61) *HIATUS: Hiatuses after a single short vowel are not allowed.

With this constraint, we can explain why observations of the type /hɪ.at/ do not occur. We also have countered the other arguments that were a reason to assume a binary rhyme requirement, hence we have demonstrated that it is possible to abolish ambisyllabicity. This answers our third research question: ambisyllabicity as used in Van der Hulst (1985) should be eliminated, so that we can reserve the ambisyllabic/geminate structure for the result of degemination. Then, the phonetic device can use this structure to differentiate contexts with a single consonant from contexts with double consonants. As such, complete degemination is possible through this device, though it is not necessarily the case that all ambisyllabic/geminate structures are categorically degeminated.

The solution to represent double consonants as geminate structures can thus not only explain our data, but also provides satisfying answers to our research questions. The first solution, making use of fake geminates, could neither provide insight in the workings of ambisyllabicity nor in the resulting configuration of degemination as well as the optionality of degemination.

[1]Although some speakers pronounce words like *aorta* 'aorta' as [ɑ.ɔr.ta], or even *marathon* 'marathon' as mɑ.ra.tɔn. We consider these pronunciations as idiosyncratic variants that need to be further investigated. For the moment, we agree with Van der Hulst (1985) on the absence of hiatuses after a short vowel

Hence, in order to account for the results in our experiments, we prefer the solution involving geminate structures instead of relying on fake geminates.

Chapter 6. Conclusion

The present thesis focused on two axes. First of all, we wanted to test the validity of ambisyllabicity. Though ambisyllabicity originated from the idea that tense vowels are underlyingly long and lax vowels underlyingly short (Van der Hulst, 1984, 1985), this idea was already falsified by Gussenhoven (2009). However, the concept of ambisyllabicity itself was never questioned before. In other Germanic languages (e.g. English and German), ambisyllabicity was also assumed, but for these languages, the arguments in favor of ambisyllabicity have been countered by Jensen (2000). The fact that ambisyllabic consonants share the same underlying representation as geminates did not seem to be a reason against ambisyllabicity, since Dutch had a degemination rule.

The second axis focused on geminated and degemination. We distinguish fake geminates from true geminates in the sense that fake geminates are represented by two identical segments that are next to each other by coincidence, and true geminates have a clearly linked structure. In Dutch, it is possible to have two identical consonants after each other, for instance when a morpheme ends in the same consonant as the following morpheme starts with. Dutch, however, is assumed to apply degemination, such that even fake geminates are excluded. The described context (e.g. *veeggebied*) should then become homophoneous with a morpheme ending in a vowel followed by a morpheme starting with a consonant (e.g. *veegebied*). The resulting structure of degemination can either be the same as single onset consonants (Booij, 1995; Jacobs et al., to appear) or the same as ambisyllabic consonants (Gussenhoven, 1986b). We do not know which of these two is true, since ambisyllabic consonants have the same duration as single consonants (Jongman, 1998; Van der Hulst, 1984, 1985). Recent experiments (Jacobs et al., to appear; Martens & Quene, 1994; Te Riele et al., 1997) have shown that degemination is not always applied, but the circumstances for application of this rule were not clear.

By means of our production and perception experiment, we have been able to show that indeed degemination is not consistently applied. On average, speakers produce a difference of up to 34 milliseconds between single and double consonants. For plosives, the average differences were not perceived, but for fricatives, nasals and liquids, listeners were able to correctly identify the minimal pairs we created. Since glides were correctly identified even when the original speaker did not produce a difference between the single or double glide, we cannot be sure of the (non-)application of degemination with these consonants. For fricatives, nasals and liquids, the difference between single and double consonants is, on average, not neutralized.

The result is problematic if we were to assume that degemination applies in the way current phonological theory describes. If degemination would result in single consonants, there would be no structural difference between *veegebied* and *veeggebied*, while in our experiments there was. If degemination would result in ambisyllabic consonants, there would be a contrast between single and ambisyllabic consonants in the case of *veegebied–veeggebied*, but not between single and ambisyllabic consonants in the case of *kapen–kappen*. So, in order to explain our data, we could either assume that degemination is simply not applied in these cases, or we could change the structural representations of *kapen* and *kappen* such that contrast between single and ambisyllabic consonants is possible.

We believe that assuming the non-application of degemination in the cases of fricatives, nasals and liquids is not satisfying. Besides the fact that such explication is not explaining how degemination nor ambisyllabicity is actually working, it would make degemination a rather categorical process, while in fact it seems that it is a gradual phenomenon. If this is true, the phonetic device should receive a specific structure of which it knows it can vary the consonantal length. Such a structure could be the representation of fake geminates, but what would than be the resulting representation if degemination is indeed completely? Furthermore, fake geminates imply the absence of any connection between the two consonants, though we believe there should be at least some degree of connection between them.

Instead, we propose to abolish the ambisyllabic representation for intervocalic consonants preceded by lax vowels. As such, *kapen* and *kapen* will have the same representation for the intervocalic vowel, which could explain why these two segments have the same duration. *Veegebied* could then contrast with *veeggebied*, if we assume that the combination of two identical consonants lead to a ambisyllabic/geminate structure. The phonetic device will than always be able to recognize an ambisyllabic/geminate structure and decide whether is wants it to be realized as short or long.

The consequences of abolishing ambisyllabicity are rather small. Since tense vowels already form an exception to the binary rhyme constraint that requires short consonants to be followed by a coda or an ambisyllabic consonant, lax vowels could be an exception as well. The validity of this binary constraint is further questioned by the occurrence of word-final lax vowel in exclamations and loan words. Within an Optimality Theory framework, the constraint that caused ambisyllabicity (i.e. LAX+C) can be easily replaced by a constraint that prevents lax vowel from lengthening: LAXV-μ, without affecting the assignment of main stress.

These conclusions of this thesis could possibly affect the orthography of Dutch. Orthographically, *kapen* and *kappen* are distinct from each other by the number of consonants. This seems valid if we assume different structures for this consonant (resp. single onset versus ambisyllabic). However, when we take into consideration that the phonological feature distinguishing the *a* in *kapen* from the *a* in *kappen* is tenseness instead of length, and that the results of our experiments favor the elimination of the structural differences between the *p*s, the current orthography is not in line with the phonological representation anymore. If we can indeed maintain the elimination of ambisyllabicity in Dutch, it might perhaps be better to write *kapen* as *kaapen* and *kappen* as *kapen*.

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Appendix A. Glossary production experiment

All 66 items of the production experiment, accompanied with their pronunciation and English glosses are listed in this appendix. Tables A.1 until including A.5 contain words with resp. plosive, fricative, nasal, liquid and glide focus consonants of the degemination, Table A.6 contains all words of the ambisyllabic word pairs.

Consonant	Word	Pronunciation	Glosses
[p]	kruipaaltje	/krœyp + paltje/	'drift.1SG + pole.DIM'
	kruippaaltje	/krœy + paltje/	'crawl.1SG + pole.DIM'
	stropotje	/stro + potje/	'straw + pot.DIM'
	strooppotje	/strop + potje/	'syrup + pot.DIM'
[t]	bijteentje	/bɛi + tentjə/	'side + toe.DIM'
	bijtteentje	/bɛit + tentjə/	'bite + toe.DIM'
	meeturen	/me+tyrə/	'watch together'
	meetturen	/met+tyrə/	'finishing line + watch'
[k]	BH-koper	/beha+kopər/	'bra + buyer'
	hooihaakkoper	/hojhak+kopər/	'hay hook + buyer'
	pi-koorts	/pi+korts/	'pi fever'
	piekkoorts	/pik+korts/	'peak fever'

Table A.1: Plosive degemination word pairs

Consonant	Word	Pronunciation	Glosses
[f]	G-frequentie	/xe+frəkwɛntsi/	‘G + frequency’
	geeffrequentie	/xef+frəkwɛntsi/	‘give.1SG + frequency’
	zee-franje	/ze+frɑnjə/	‘sea + fringe’
	zeef-franje	/zef+frɑnjə/	‘seaf + fringe’
	die festivals	/di+fɛstivɑls/	‘that + festivals’
	dieffestivals	/dif+fɛstivɑls/	‘thief + festivals’
[s]	kruisteken	/krœys + teken/	‘cross + sign’
	kruissteken	/krœys + steken/	‘cross + stick’
	eisapje	/ɛi+sɑpjə/	‘egg + juice.DIM’
	ijssapje	/ɛis+sɑpjə/	‘ice + juice.DIM’
	eisoepje	/ɛi+supjə/	‘egg + soup.DIM’
	ijssoepje	/ɛis+supjə/	‘ice + soup.DIM’
[x]	steegrachtje	/ste+xrɑxtje/	‘spot + canal.DIM’
	drooggrachtje	/drog+xrɑxtje/	‘dry + canal.DIM’
	lagaatje	/la+xatje/	‘drawer + hole.DIM’
	laaggaatje	/lax+xatjeə/	‘low + hole.DIM’
	veegebied	/ve+xebid/	‘cattle + area’
	veeggebied	/vex+xebid/	‘sweep.1SG + area’

Table A.2: Fricative degemination word pairs

Consonant	Word	Pronunciation	Glosses
[m]	rijmeester	/rɛi+mestər/	'drive.1SG + master'
	rijmmeester	/rɛim+mestər/	'rime.1SG + master'
	steeman	/ste+mɑn/	'spot + man'
	systeemman	/sistem+mɑn/	'system + man'
[n]	meinummer	/mɛi+nʏmər/	'mai + number'
	mijn nummer	/mɛin+nʏmər/	'my number'
	zijnetje	/zɛi+nɛtjə/	'side + net.DIM'
	zijn netje	/zɛin+nɛtjə/	'his + net.DIM'

Table A.3: Nasal degemination word pairs. N.B.: Dutch has no words starting in [ŋ].

Consonant	Word	Pronunciation	Glosses
[l]	koeluchtje	/ku+lʏxtjə/	'cow + air.DIM'
	koelluchtje	/kul+lʏxtjə/	'cool + air.DIM'
	zijlatje	/zɛi+lɑtjə/	'side + bar.DIM'
	zeillatje	/zɛil+lɑtjə/	'sail + bar.DIM'
[r]	ja-regeling	/ja+regəlɪŋ/	'yes + regulation'
	jaarregeling	/jaar+regəlɪŋ/	'year + regulation'
	meereizen	/me+rɛizə/	'travel along'
	meerreizen	/mer+rɛizə/	'lake + travel'

Table A.4: Liquid degemination word pairs

Consonant	Word	Pronunciation	Glosses
[j]	strojongen	/stro+jɔŋən/	‘straw + boy’
	strooijongen	/stroj+jɔŋən/	‘scatter.1SG + boy’
	strojasje	/stro+jɑsjə/	‘straw + coat.DIM’
	strooijasje	/stroj+jɑsjə/	‘scatter.1SG + coat.DIM’
[w]	zeewater	/ze+watər/	‘sea + water’
	zeeuwwater	/zew+watər/	‘native of Zeeland + water’
	machowaarzegger	/mɑtʃo+warzɛxər/	‘macho + soothsayer’
	showwaarzegger	/ʃow+warzɛxər/	‘show + soothsayer’

Table A.5: Glide degemination word pairs

Consonant	Word	Pronunciation	Glosses
[p]	kapen	/kapə/	‘capes’ (N) or ‘to hijack’ (V)
	kappen	/kɑpə/	‘caps’ (N) or ‘to chop’ (V)
[t]	pieten	/pitə/	‘fellers’ (N) or ‘to accuse’ (V)
	pitten	/pɪtə/	‘seeds’ (N) or ‘to sleep’ (V)
[k]	roken	/rokə/	‘to smoke’
	rokken	/rɔkə/	‘skirts’
[m]	ramen	/ramə/	‘windows’ (N) or ‘to assess’ (V)
	rammen	/rɑmə/	‘rams’ (N) or ‘to bash in/down’ (V)
[r]	sparen	/sparə/	‘to save’
	sparren	/spɑrə/	‘spruces’ (N) or ‘to work out’ (V)
[j]	sproeien	/sprujə/	‘to spray’
[w]	duwen	/dywə/	‘to push’

Table A.6: Ambisyllabic word pairs

Appendix B. Results production experiment

B.1 Degemination word pairs

The four tables in this section present all individual measurements of absolute and relative duration of the focus consonants in the degemination word pairs of the production experiment. Table B.1 reports the measurements from Amsterdam, Table B.2 shows the measurements from Uden, Table B.3 presents this data from Zierikzee, and finally, Table B.4 reports the measurements from Zwolle. Each table is ordered in the same way, starting with the words containing degemination pairs of which the focus consonant is a plosive, followed by the pairs representing the fricatives, then resp. nasals, liquids and glides. For each word produced by a participant, two values are given: the top value represents the absolute duration of the focus consonant in milliseconds, the bottom value represents the relative duration of this consonant compared to the duration of the preceding vowel. If it was not possible to determine either the absolute or the relative duration of a speaker (i.e. due to mispronunciation or insertion of a small pause between two words), this is marked by a long hyphen ('—').

Table B.1: Results of the degemination word pairs of the production experiment in Amsterdam

word	1	2	3	4	5	6	7	8	9	10	11
kruipaaltje	112	—	181	105	93	106	106	76	95	103	110
	0.84		1.10	0.61	0.59	0.90	0.66	0.55	0.62	0.80	0.84
kruippaaltje	—	104	—	126	97	102	158	209	110	125	120
		0.69		1.02	0.72	1.23	0.87	1.33	0.90	0.91	0.88
stropotje	99	88	113	82	107	100	80	75	98	90	75
	0.69	0.90	0.85	0.65	0.83	1.14	0.55	0.49	0.86	0.72	0.52
strooppotje	127	—	259	314	103	96	187	120	234	100	221
	1.08		2.27	2.04	0.76	0.73	1.36	0.96	2.36	0.94	2.28

Table B.1: Results of the degemination word pairs of the production experiment in Amsterdam, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11
bijteentje	86	98	90	110	81	88	98	99	91	214	92
	0.51	0.46	0.51	0.62	0.44	0.58	0.60	0.54	0.56	0.85	0.51
bijt-teentje	309	—	—	121	77	134	203	189	—	126	—
	1.53			0.79	0.42	0.87	1.22	1.09		0.90	
meeturen	116	128	147	122	113	112	105	94	107	136	157
	0.63	0.71	0.98	0.77	0.73	0.73	0.61	0.64	0.68	0.96	1.13
meet-turen	—	—	—	—	72	59	201	—	—	—	235
					0.41	0.41	1.39				1.79
BH-koper	93	106	119	102	74	94	89	89	129	99	113
	0.48	0.59	0.82	0.69	0.48	0.65	0.56	0.60	0.82	0.76	0.72
hooihaakkoper	—	148	—	243	96	103	—	111	246	—	—
		1.13		1.90	0.78	0.82		0.82	1.80		
pi-koorts	100	126	129	161	101	104	166	117	125	150	119
	0.99	1.48	1.56	2.20	1.34	1.12	1.81	1.49	1.24	1.88	1.13
piekkoorts	141	—	—	179	134	139	147	209	228	—	127
	2.01			2.52	1.54	1.70	1.94	2.49	3.20		1.31
G-frequentie	141	83	176	94	89	67	142	117	119	126	70
	1.07	0.58	1.01	0.65	0.55	0.49	0.88	0.87	0.79	0.86	0.48
geeffrequentie	117	—	—	100	89	93	—	124	239	106	116
	0.84			0.71	0.70	0.74		1.12	1.39	0.83	0.84
zee-franje	—	133	120	111	86	117	99	113	139	136	117
		0.78	0.73	0.63	0.63	0.79	0.63	0.65	0.83	0.79	0.66
zeef-franje	—	—	—	97	118	131	223	293	242	—	334
				0.54	0.88	0.87	1.17	2.40	1.30		1.90
die festivals	121	122	88	95	90	96	110	89	93	111	—
	1.54	1.88	0.89	1.14	1.37	1.72	1.47	0.98	1.06	0.99	
dieffestivals	—	—	—	—	—	104	227	252	417	146	133
						0.82	2.08	2.01	3.12	1.39	1.44
kruis-teken	40	56	—	167	45	141	119	153	136	172	146
	0.25	0.45		1.04	0.27	0.88	0.72	0.98	0.80	1.35	1.05
kruis-steken	39	73	173	54	140	128	175	290	151	167	176
	0.27	0.42	0.92	0.37	1.02	0.78	1.51	1.93	1.11	1.23	1.05
eisapje	111	160	116	139	95	88	125	116	122	—	137
	0.58	1.18	0.70	0.96	0.75	0.53	0.68	0.69	0.65		0.91

Table B.1: Results of the degemination word pairs of the production experiment in Amsterdam, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11
ijssapje	132	101	—	134	137	117	269	214	138	116	125
	0.89	0.62		0.97	0.92	0.76	1.67	1.30	1.05	0.78	1.09
eisoepje	139	119	143	153	121	99	118	220	141	105	122
	0.95	0.55	1.00	0.81	0.77	0.54	0.73	1.34	0.83	0.69	0.82
ijssoepje	146	184	147	148	126	121	272	275	136	123	172
	0.94	1.06	1.21	1.01	0.98	0.56	1.76	2.32	0.86	0.81	1.18
stee-grachtje	104	119	122	114	96	81	52	114	89	100	100
	0.66	0.86	0.94	0.80	0.80	0.76	0.32	0.67	0.49	0.76	0.66
droog grachtje	186	—	—	117	136	151	—	221	—	134	—
	1.22			1.02	1.05	1.49		1.42		0.85	
lagaatje	144	134	107	125	109	151	153	124	121	114	122
	1.09	1.63	0.58	2.28	0.77	1.33	2.02	0.81	1.48	0.98	1.94
laaggaatje	156	—	361	162	128	—	137	—	216	178	281
	1.09		2.15	1.05	0.88		0.90		1.39	1.42	1.91
veegebied	44	138	128	71	100	72	51	127	92	108	99
	0.28	0.78	0.85	0.51	0.72	0.56	0.35	0.88	0.67	0.69	0.72
veeggebied	103	212	120	91	107	69	96	143	236	118	188
	0.71	1.53	0.80	0.57	0.83	0.52	0.67	1.07	1.41	0.86	1.19
steeman	98	95	83	106	74	56	95	87	75	79	94
	0.72	0.72	0.58	0.62	0.55	0.43	0.70	0.62	0.52	0.67	0.68
systeemman	90	107	120	115	92	88	97	164	108	101	148
	0.66	0.75	0.91	0.84	0.66	0.80	0.73	1.07	0.75	0.84	1.35
rijmeester	99	110	—	92	64	99	96	99	88	—	90
	0.66	0.72		0.74	0.34	0.61	0.54	0.54	0.63		0.71
rijmmeester	110	99	—	124	87	90	162	98	114	117	116
	0.74	0.73		0.73	0.58	0.93	0.96	0.77	0.83	0.79	0.88
meinummer	109	66	102	92	62	81	—	74	88	76	77
	0.50	0.37	0.73	0.64	0.36	0.60		0.46	0.61	0.61	0.43
mijn nummer	62	69	91	90	88	143	92	101	93	91	65
	0.59	0.65	0.90	1.20	1.00	1.06	0.71	0.93	0.76	0.99	0.49
zijnetje	83	58	77	96	61	87	79	72	105	73	65
	0.41	0.31	0.48	0.46	0.40	0.78	0.57	0.44	0.58	0.56	0.39
zijn netje	131	—	89	103	99	116	—	—	126	77	87
	0.98		0.82	1.12	1.18	0.94			0.76	1.10	0.67

Table B.1: Results of the degemination word pairs of the production experiment in Amsterdam, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11
koeluchtje	115	—	60	84	63	63	81	83	117	60	92
	0.83		0.33	1.07	0.46	0.72	1.07	0.71	1.38	0.93	1.11
koelluchtje	120	—	—	73	71	84	70	155	74	76	84
	0.83			0.66	0.69	1.34	1.24	1.07	0.57	0.88	0.58
zijlatje	72	75	81	84	59	73	69	60	66	—	77
	0.40	0.52	0.54	0.50	0.39	0.57	0.51	0.39	0.42		0.51
zeillatje	128	109	82	136	125	127	86	157	142	98	99
	0.79	0.53	0.48	1.24	0.96	1.09	0.61	1.74	0.90	0.93	0.82
ja-regeling	44	—	77	58	65	53	52	35	—	66	39
	0.31		0.45	0.33	0.43	0.37	0.36	0.22		0.66	0.26
jaarregeling	61	45	86	60	51	55	—	156	45	71	31
	0.38	0.25	0.49	0.34	0.33	0.41		0.91	0.26	0.53	0.25
meereizen	42	43	58	56	33	59	54	38	44	39	50
	0.21	0.25	0.30	0.34	0.21	0.39	0.29	0.23	0.30	0.26	0.34
meerreizen	64	61	91	52	52	49	40	79	39	91	76
	0.38	0.44	0.46	0.32	0.32	0.24	0.23	0.45	0.21	0.62	0.49
strojasje	93	—	118	86	62	91	90	83	69	74	—
	0.66		0.75	0.50	0.39	0.73	0.82	0.61	0.57	0.78	
strooijasje	123	—	—	115	95	105	—	—	—	119	116
	1.00			0.84	0.78	0.86				0.94	0.78
strojongen	99	124	98	126	127	88	87	70	70	68	100
	0.72	1.39	0.98	0.79	0.92	0.71	0.70	0.53	0.44	0.47	0.84
strooijongen	87	—	138	118	99	93	81	124	101	101	186
	0.77		1.10	0.94	0.72	1.00	0.64	1.35	1.18	0.88	1.36
showwaarzegger	—	98	102	75	51	57	87	90	—	117	192
		0.69	0.70	0.46	0.40	0.53	0.71	0.57		0.92	1.25
macho-waarzegger	97	83	98	77	53	67	78	76	86	64	95
	0.97	1.44	0.76	1.03	0.57	0.70	0.81	0.98	0.80	0.59	0.86
zeewater	92	75	77	67	78	74	98	68	60	88	68
	0.59	0.76	0.55	0.42	0.56	0.57	0.67	0.41	0.41	0.74	0.50
Zeeuw-water	143	—	296	114	107	137	175	141	—	100	229
	0.75		2.14	0.89	0.74	0.93	0.82	1.31		0.59	1.83

Table B.2: Results of the degemination word pairs of the production experiment in Uden

word	1	2	3	4	5	6	7	8	9	10	11	12
kruipaaltje	91	132	116	116	103	78	102	103	88	166	123	113
	0.69	0.88	0.74	0.93	0.65	0.62	0.72	0.68	0.57	0.92	0.88	0.63
kruippaaltje	—	—	97	98	194	87	368	201	116	158	—	115
			0.66	0.57	1.27	0.78	2.14	1.52	0.79	1.08		1.15
stropotje	87	130	120	110	98	80	108	98	91	135	118	122
	0.65	1.51	0.87	0.68	0.66	0.67	1.11	0.79	0.73	0.91	1.12	0.67
strooppotje	109	95	102	139	182	120	103	111	116	140	136	105
	0.99	0.76	0.77	0.90	1.27	1.11	0.78	0.88	1.12	1.12	1.33	0.71
bijteentje	153	108	105	105	113	80	—	89	106	129	124	80
	0.93	0.64	0.60	0.58	0.64	0.61		0.66	0.65	0.75	0.68	0.40
bijt-teentje	253	—	115	118	182	—	108	—	119	—	193	105
	1.41		0.64	0.68	0.98		0.65		0.77		1.30	0.83
meeturen	91	—	74	—	137	—	—	107	108	—	—	119
	0.66		0.52		0.84			0.79	0.76			0.79
meet-turen	104	—	117	119	201	247	122	155	244	—	—	139
	0.72		0.81	0.81	1.35	1.93	1.05	1.41	1.87			0.98
BH-koper	113	—	107	103	117	100	85	104	107	128	107	110
	0.88		0.70	0.78	0.76	0.72	0.59	0.68	0.68	0.65	0.97	0.70
hooihaakkoper	135	—	108	140	—	—	120	125	139	146	—	123
	1.04		0.75	0.95			0.83	1.15	1.12	1.01		0.75
pi-koorts	122	122	111	115	101	92	107	142	128	130	118	108
	1.45	1.36	1.15	1.38	1.11	1.37	1.35	1.32	1.49	1.59	1.45	1.33
piekkoorts	110	—	94	148	155	132	138	129	138	—	244	119
	1.68		0.98	1.97	1.70	2.34	1.78	1.91	1.79		2.40	1.45
G-frequentie	120	142	88	98	85	90	116	106	99	152	118	85
	0.82	0.85	0.59	0.66	0.47	0.75	0.68	0.86	0.75	0.92	0.78	0.55
geeffrequentie	94	112	89	74	—	114	108	82	109	115	158	104
	0.80	0.87	0.58	0.51		0.88	0.79	0.73	0.95	0.82	1.11	0.69
zee-franje	102	106	105	125	126	81	115	117	77	142	—	96
	0.79	0.73	0.98	0.87	0.73	0.61	0.95	1.10	0.52	0.78		0.81
zeef-franje	—	206	105	104	—	213	144	143	125	172	—	109
		1.30	0.76	0.66		1.74	1.17	1.08	0.85	1.14		0.69
die festivals	108	147	103	116	116	102	—	124	101	105	134	112
	2.48	2.02	1.79	1.80	1.82	1.74		1.76	1.38	1.18	1.59	1.48

Table B.2: Results of the degemination word pairs of the production experiment in Uden, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11	12
dieffestivals	242	242	123	131	133	106	137	173	137	—	208	116
	2.87	2.62	1.72	1.50	1.53	1.43	1.58	1.98	1.69		2.12	1.30
kruis-teken	127	152	172	149	159	140	139	153	104	182	240	157
	1.05	1.21	1.12	1.01	1.16	1.18	1.13	1.35	0.85	1.13	1.39	1.23
kruis-steken	131	113	—	138	158	155	154	190	170	294	—	171
	0.97	0.65		0.95	0.91	1.17	1.10	1.28	1.21	1.76		1.03
eisapje	103	99	130	120	102	116	110	133	125	135	179	136
	0.72	0.65	0.77	0.73	0.62	0.88	0.69	0.86	0.79	0.78	0.94	0.79
ijssapje	—	118	143	130	138	118	126	145	144	143	169	138
		0.69	0.98	0.94	1.00	0.96	0.92	0.85	0.97	0.95	1.22	0.91
eisoepje	110	121	130	117	—	161	144	121	113	146	—	143
	0.77	0.78	0.83	0.72		1.46	1.25	0.63	0.81	0.79		0.97
ijssoepje	136	211	128	142	—	—	134	—	155	174	—	151
	1.05	1.33	0.81	0.95			0.91		1.08	1.06		0.77
stee-grachtje	61	86	73	95	67	52	74	120	91	113	—	85
	0.36	0.51	0.45	0.57	0.33	0.40	0.57	0.87	0.61	0.59		0.51
droog grachtje	158	—	123	169	152	—	87	119	112	159	136	111
	1.12		0.89	1.09	1.03		0.71	1.14	1.53	0.89	1.15	0.77
lagaatje	66	67	102	111	—	66	112	—	78	140	88	83
	0.62	0.51	0.69	1.04		0.92	2.21		0.53	0.65	0.87	1.19
laaggaatje	162	120	134	141	166	43	—	152	142	141	143	70
	1.33	1.06	0.98	0.84	0.91	0.55		1.21	0.91	0.86	0.83	0.66
veegebied	73	62	70	64	78	62	42	118	68	124	69	77
	0.51	0.38	0.42	0.36	0.44	0.49	0.27	0.87	0.43	0.71	0.50	0.38
veeggebied	96	216	101	100	123	108	101	124	86	—	—	114
	0.82	1.44	0.66	0.60	0.74	0.95	0.70	0.92	0.55			0.75
steeman	79	82	77	84	92	58	80	73	73	76	97	88
	0.69	0.55	0.54	0.52	0.57	0.56	0.47	0.61	0.56	0.45	0.73	0.51
systeemman	98	112	124	95	100	61	59	91	120	141	113	90
	0.70	0.72	0.84	0.66	0.76	0.65	0.51	0.80	1.05	1.04	0.77	0.52
rijmeester	74	70	88	87	83	62	53	78	69	77	57	80
	0.50	0.45	0.53	0.51	0.42	0.54	0.32	0.53	0.52	0.40	0.40	0.44
rijmmeester	113	98	100	110	194	56	—	180	107	75	—	101
	0.82	0.66	0.70	0.66	1.22	0.36		1.24	0.78	0.55		0.50

Table B.2: Results of the degemination word pairs of the production experiment in Uden, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11	12
meinummer	53	74	74	95	57	57	51	61	57	115	80	54
	0.49	0.47	0.50	0.58	0.30	0.44	0.36	0.38	0.44	0.49	0.58	0.31
mijn nummer	73	127	68	97	76	59	65	61	110	79	77	71
	0.80	0.84	0.58	1.06	0.67	0.57	0.56	0.66	1.03	0.52	0.62	0.61
zijnetje	54	82	56	61	46	49	48	—	66	69	75	67
	0.35	0.39	0.35	0.32	0.24	0.38	0.34		0.41	0.36	0.44	0.37
zijn netje	—	87	79	87	76	73	80	—	98	87	—	83
		0.67	0.64	0.79	0.78	0.83	0.56		0.90	0.46		0.90
koeluchtje	79	82	56	72	63	57	30	—	66	62	—	67
	0.45	0.74	0.58	0.78	0.64	0.76	0.38		0.80	0.38		0.47
koelluchtje	76	95	103	87	133	62	51	84	108	135	78	104
	0.59	1.05	1.04	1.22	1.44	0.84	0.59	0.99	1.04	0.97	0.73	0.82
zijlatje	49	54	61	54	46	—	34	60	65	74	57	53
	0.48	0.32	0.34	0.29	0.36		0.25	0.41	0.43	0.37	0.39	0.29
zeillatje	59	112	66	65	136	62	50	117	91	—	110	59
	0.45	0.59	0.38	0.34	0.71	0.41	0.40	0.90	0.54		0.50	0.30
ja-regeling	53	65	102	54	43	—	66	61	45	72	62	65
	0.30	0.43	0.67	0.29	0.24		0.43	0.51	0.39	0.37	0.47	0.39
jaarregeling	52	84	74	49	50	116	—	54	82	90	67	85
	0.30	0.56	0.50	0.27	0.26	1.17		0.38	0.55	0.52	0.49	0.48
meereizen	58	54	63	50	58	45	42	32	28	58	48	45
	0.28	0.30	0.33	0.25	0.31	0.36	0.31	0.19	0.12	0.32	0.25	0.28
meerreizen	60	59	74	37	45	80	39	46	45	164	59	66
	0.36	0.36	0.50	0.17	0.24	0.87	0.29	0.30	0.27	0.90	0.44	0.41
strojasje	96	66	62	70	68	66	—	68	73	98	89	88
	0.81	0.49	0.60	0.45	0.48	0.54		0.37	0.59	0.68	0.44	0.59
strooijasje	—	94	83	98	92	217	—	91	85	70	186	99
		1.01	0.62	0.58	0.58	1.89		0.69	0.65	0.47	1.25	0.80
strojongen	85	82	76	77	77	82	75	90	62	86	86	88
	0.54	0.68	0.62	0.48	0.43	0.68	0.72	0.58	0.40	0.43	0.55	0.77
strooijongen	113	107	79	75	141	81	52	78	93	133	109	112
	1.07	0.81	0.53	0.42	0.94	0.80	0.47	0.61	0.57	0.81	0.78	0.86
showwaarzegger	67	99	61	44	51	54	—	131	70	97	68	85
	0.49	0.73	0.41	0.21	0.35	0.49		1.21	0.52	0.54	0.53	0.52

Table B.2: Results of the degemination word pairs of the production experiment in Uden, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11	12
macho-waarzegger	81	45	47	53	—	86	—	111	51	44	—	64
	1.39	0.44	0.58	0.45		0.85		1.41	0.46	0.34		0.78
zeewater	71	75	59	46	55	68	64	68	56	75	56	43
	0.49	0.46	0.40	0.25	0.35	0.61	0.45	0.41	0.35	0.39	0.36	0.25
Zeeuw-water	97	105	61	60	80	84	53	90	117	105	64	50
	0.89	0.53	0.47	0.30	0.48	0.93	0.43	0.59	0.68	0.59	0.36	0.35

Table B.3: Results of the degemination word pairs of the production experiment in Zierikzee

word	1	2	3	4	5	6	7	8	9	10	11	12
kruipaaltje	135	109	100	87	107	188	111	—	274	107	99	137
	0.77	0.67	0.94	0.68	0.75	1.28	0.74		1.58	1.00	0.78	0.92
kruippaaltje	—	108	90	94	—	131	98	123	128	155	124	132
		0.81	0.57	0.75		1.17	0.69	0.76	0.79	1.19	1.41	1.10
stropotje	132	117	80	93	112	94	93	103	102	114	88	116
	0.96	1.19	0.70	0.73	1.01	0.89	0.68	0.84	0.77	1.21	0.71	1.07
strooppotje	129	115	91	127	163	124	138	128	—	—	129	157
	0.98	1.09	0.88	1.16	1.39	1.61	1.19	1.05			1.03	1.02
bijteentje	120	113	74	88	110	122	112	151	122	108	141	106
	0.67	0.76	0.44	0.59	0.83	1.01	0.65	1.03	0.81	0.76	0.91	0.57
bijt-teentje	—	—	—	105	—	—	114	159	—	—	126	196
				0.74			0.63	1.03			0.91	1.16
meeturen	133	133	122	95	126	129	133	135	149	114	—	146
	0.74	1.00	0.82	0.67	0.94	1.11	0.90	1.10	0.94	1.09		0.89
meet-turen	—	119	—	—	—	133	133	168	—	—	177	—
		0.92				1.25		1.35			1.55	
BH-koper	123	116	—	125	107	—	119	119	123	104	106	—
	0.66	0.89		0.97	1.02		0.78	0.98	0.92	0.98	1.08	
hooihaakkoper	127	139	158	—	137	135	145	150	138	—	—	—
	0.70	1.36	1.02		1.15	1.34	0.96	0.88	0.90			
pi-koorts	124	118	98	115	133	155	114	143	141	109	125	159
	1.58	1.48	1.49	1.81	1.75	2.67	1.07	1.04	1.45	1.54	1.58	1.37
piekkoorts	131	153	103	149	164	168	140	145	—	148	132	—
	1.77	2.33	2.73	2.71	2.66	3.25	1.55	1.48		2.18	1.79	

Table B.3: Results of the degemination word pairs of the production experiment in Zierikzee, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11	12
G-frequentie	135	124	107	115	105	66	133	109	140	129	119	101
	0.77	1.08	0.71	0.69	1.00	0.49	0.56	0.64	0.89	0.93	0.87	0.85
geeffrequentie	151	—	118	—	136	65	—	—	147	140	146	262
	1.03		0.92		1.26	0.63			1.30	1.06	1.43	1.49
zee-franje	—	110	132	—	143	109	140	92	158	84	98	144
		0.81	0.86		0.80	1.12	0.92	0.80	1.03	0.62	0.61	1.01
zeef-franje	150	121	121	367	470	109	—	125	151	151	167	240
	0.85	0.89	0.80	2.46	2.79	1.21		0.97	0.97	1.08	1.25	1.18
die festivals	141	—	110	114	119	101	139	145	133	84	130	129
	1.74		1.45	1.49	1.91	1.83	1.74	1.77	1.43	1.03	2.64	1.91
dieffestivals	—	130	177	—	159	144	—	137	129	—	145	213
		1.47	2.25		2.09	1.87		1.39	1.16		1.66	2.12
kruis-teken	101	146	168	155	113	137	164	151	199	165	145	195
	0.59	1.14	1.14	1.23	0.92	1.26	1.09	0.80	1.41	1.25	1.01	1.23
kruis-steken	212	156	146	163	128	132	183	169	203	172	164	167
	1.56	1.25	0.95	1.21	0.82	1.22	1.34	1.03	1.20	1.25	1.14	1.14
eisapje	142	133	120	149	154	101	142	139	131	128	113	150
	0.77	1.07	0.90	1.00	0.67	0.68	0.96	0.70	0.81	0.95	0.78	0.75
ijssapje	172	156	150	115	140	126	157	149	161	125	150	271
	0.86	1.33	0.96	0.89	0.90	1.31	0.92	0.92	1.00	0.99	1.09	1.77
eisoepje	160	143	116	122	—	—	154	146	164	139	116	144
	0.91	1.28	0.83	0.88			0.93	0.84	1.02	1.03	0.91	0.62
ijssoepje	152	159	133	—	139	—	153	160	169	156	144	167
	0.72	1.54	1.01		1.26		1.07	0.98	1.12	1.17	1.08	1.11
stee-grachtje	148	101	88	—	178	130	109	114	117	106	130	113
	0.67	0.83	0.46		0.99	1.54	0.62	0.79	0.62	0.84	0.97	0.74
droog grachtje	—	102	123	110	113	109	—	143	160	—	147	229
		1.32	0.80	0.94	1.10	0.77		1.09	0.77		1.19	1.53
lagaatje	—	—	89	135	103	—	166	135	—	157	133	130
			2.14	1.23	0.64		1.66	1.18		1.03	1.16	1.91
laaggaatje	146	186	—	312	162	113	177	159	164	146	135	163
	0.90	1.42		2.62	1.23	1.04	1.10	1.16	1.28	1.23	1.01	1.03
veegebied	86	80	71	66	—	81	89	71	—	103	77	91
	0.48	0.57	0.47	0.41		0.90	0.52	0.38		0.79	0.51	0.47

Table B.3: Results of the degemination word pairs of the production experiment in Zierikzee, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11	12
veeggebied	164	126	—	127	97	106	71	113	157	132	172	194
	0.93	0.92		0.98	0.70	0.95	0.38	0.62	1.03	0.94	1.09	1.16
steeman	107	94	74	74	58	81	70	87	96	66	80	98
	0.70	0.74	0.51	0.54	0.46	1.06	0.49	0.54	0.61	0.47	0.60	0.47
systeemman	118	106	93	107	98	110	94	90	—	93	96	120
	0.77	0.89	0.71	0.88	0.83	1.05	0.63	0.65		0.78	0.76	0.77
rijmeester	71	76	77	65	60	64	77	97	78	—	67	67
	0.54	0.52	0.49	0.44	0.44	0.53	0.40	0.62	0.46		0.46	0.40
rijmmeester	86	106	73	—	90	74	82	133	133	92	101	—
	0.44	0.74	0.49		0.62	0.76	0.47	0.91	0.82	0.81	0.70	
meinummer	65	—	54	88	43	64	73	84	132	84	69	47
	0.41		0.33	0.62	0.35	0.49	0.40	0.65	0.82	0.87	0.53	0.27
mijn nummer	74	91	67	84	—	83	62	93	173	135	79	147
	0.72	1.72	0.53	0.77		1.01	0.45	0.82	1.07	1.17	1.04	1.50
zijnetje	81	67	64	57	45	64	63	70	66	54	62	70
	0.42	0.54	0.42	0.36	0.27	0.44	0.35	0.35	0.36	0.34	0.40	0.40
zijn netje	—	—	68	89	126	74	88	100	—	87	72	204
			0.64	0.61	1.00	1.02	0.52	0.69		0.70	0.87	1.33
koeluchtje	105	86	33	88	118	54	94	105	101	68	51	76
	1.03	1.09	0.49	1.12	1.31	0.48	0.82	0.91	0.96	0.79	0.63	0.79
koelluchtje	84	63	51	121	89	68	77	127	169	97	72	158
	0.57	0.46	0.88	1.51	0.78	0.55	0.60	1.14	1.36	1.22	0.67	0.86
zijlatje	74	63	58	63	—	255	70	90	132	55	58	62
	0.44	0.48	0.36	0.44		1.85	0.39	0.46	0.77	0.41	0.40	0.32
zeillatje	79	48	81	98	107	57	62	—	183	92	89	83
	0.39	0.33	0.58	0.79	0.77	0.52	0.36		1.19	0.70	0.78	0.57
ja-regeling	86	37	60	62	50	68	58	70	97	53	65	65
	0.46	0.23	0.48	0.51	0.25	0.44	0.50	0.52	0.77	0.47	0.40	0.38
jaarregeling	68	47	25	51	71	50	68	54	103	40	80	56
	0.31	0.35	0.20	0.36	0.47	0.39	0.38	0.26	0.53	0.28	0.54	0.35
meereizen	—	73	45	23	77	53	48	47	77	45	78	21
		0.50	0.23	0.14	0.44	0.41	0.32	0.28	0.53	0.32	0.61	0.11
meerreizen	79	29	51	48	75	72	60	70	—	28	50	53
	0.43	0.16	0.25	0.25	0.46	0.40	0.35	0.35		0.24	0.33	0.26

Table B.3: Results of the degemination word pairs of the production experiment in Zierikzee, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11	12
strojasje	83	85	77	73	54	67	63	67	98	70	89	58
	0.63	0.78	0.88	0.59	0.45	1.17	0.39	0.48	0.62	0.52	0.74	0.38
strooijasje	96	84	—	107	96	96	148	116	—	106	90	136
	0.78	0.84		1.04	0.90	0.98	0.85	1.20		1.09	0.75	0.95
strojongen	105	88	76	63	80	79	69	100	121	100	48	85
	0.79	0.63	0.58	0.42	0.88	0.61	0.42	0.78	0.78	0.80	0.42	0.84
strooijongen	100	117	—	166	—	114	107	167	128	115	90	111
	0.62	0.90		1.63		0.90	0.86	1.51	0.69	0.78	0.65	0.55
showwaarzegger	82	58	63	104	101	86	—	89	89	79	74	84
	0.72	0.46	0.38	0.87	0.61	0.70		0.51	0.59	0.78	0.45	0.48
macho-waarzegger	78	60	45	—	58	68	106	121	80	106	68	74
	0.63	0.69	0.33		0.44	1.10	1.10	1.23	0.65	0.78	0.85	0.64
zeewater	53	52	61	86	50	43	69	78	55	42	67	53
	0.28	0.35	0.55	0.56	0.35	0.45	0.43	0.45	0.33	0.33	0.45	0.37
Zeeuw-water	193	73	—	142	96	96	77	93	—	125	120	—
	1.96	0.37		1.59	0.59	0.94	0.51	0.67		0.74	1.15	

Table B.4: Results of the degemination word pairs of the production experiment in Zwolle

word	1	2	3	4	5	6	7	8	9	10	11	12
kruipaaltje	129	81	90	128	93	145	93	127	105	144	120	115
	1.00	0.57	0.62	1.13	0.58	1.11	0.71	0.84	0.87	0.97	1.12	0.82
kruippaaltje	271	103	97	141	153	250	119	121	147	207	187	117
	2.15	0.97	0.78	1.35	1.19	1.82	0.99	1.07	1.33	1.55	1.94	0.98
stropotje	123	112	124	125	93	183	106	72	107	141	117	113
	1.34	1.12	1.01	1.19	0.84	2.03	1.09	0.60	0.94	1.24	1.28	0.89
strooppotje	148	139	124	154	128	265	—	123	—	142	123	213
	1.41	1.48	1.02	1.31	1.04	2.45		1.17		1.35	1.00	1.76
bijteentje	116	91	142	103	76	143	—	104	—	102	102	124
	0.77	0.71	0.64	0.68	0.46	1.03		0.70		0.58	0.66	0.75
bijt-teentje	—	109	113	130	124	—	—	121	111	158	—	131
		0.78	0.75	0.93	0.86			0.92	0.80	0.99		0.76
meeturen	115	111	122	109	112	183	—	115	—	—	138	102
	0.96	0.78	0.88	0.88	0.90	1.77		0.93			0.91	0.84

Table B.4: Results of the degemination word pairs of the production experiment in Zwolle, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11	12
meet-turen	—	129	229	—	—	245	—	127	—	—	172	140
		1.11	1.48			2.43		0.93			1.56	1.01
BH-koper	122	92	116	115	112	135	150	115	133	134	78	—
	1.14	0.66	0.89	0.91	0.63	0.78	1.04	0.81	0.79	1.04	0.63	
hooihaakkoper	132	117	106	136	—	—	128	168	—	142	115	—
	1.42	1.28	0.78	1.07			1.42	1.19		1.28	0.84	
pi-koorts	144	108	128	123	116	150	144	132	132	159	101	116
	1.64	1.19	1.65	1.58	2.34	2.35	2.17	2.55	1.43	2.87	1.76	1.66
piekkoorts	156	125	98	104	162	168	134	176	195	—	—	160
	2.52	1.79	1.42	1.35	2.67	3.04	2.30	3.15	3.97			2.30
G-frequentie	119	91	113	85	92	106	158	83	121	117	68	87
	0.86	0.77	0.74	0.62	0.82	0.69	1.49	0.69	1.20	0.64	0.63	0.72
geeffrequentie	262	115	169	94	103	328	99	85	—	114	93	144
	2.00	0.91	0.93	0.81	0.93	2.14	0.85	0.77		0.80	0.86	1.07
zee-franje	135	95	94	133	112	96	67	97	—	120	107	119
	0.83	0.68	0.62	0.94	1.03	0.86	0.73	0.73		0.79	0.74	0.84
zeef-franje	—	121	88	—	182	134	112	213	196	156	141	126
		0.86	0.59		1.74	1.01	1.05	1.41	1.84	1.04	0.99	0.85
die festivals	98	81	77	97	113	105	113	100	117	129	128	125
	1.25	1.57	1.18	1.30	1.93	1.80	2.53	1.40	1.76	2.42	2.55	1.83
dieffestivals	167	141	110	164	148	—	104	118	172	173	—	128
	2.06	1.86	1.24	2.00	1.58		1.51	1.50	1.94	1.94		1.55
kruis-teken	166	124	181	161	145	101	60	68	65	83	60	164
	1.46	0.88	1.17	1.41	1.03	0.89	0.61	0.51	0.58	0.49	0.56	1.12
kruis-steken	177	222	171	183	172	80	60	50	78	—	57	143
	1.20	1.47	1.07	1.23	1.24	0.59	0.45	0.35	0.68		0.49	1.04
eisapje	136	105	103	112	105	159	123	97	144	—	105	135
	0.91	0.60	0.66	0.88	0.76	0.86	0.89	0.72	1.31		0.81	0.89
ijssapje	147	148	124	122	—	179	145	122	160	—	129	167
	1.01	0.93	0.76	0.95		1.25	1.28	0.86	1.74		1.22	1.18
eisoepje	123	100	115	114	137	—	—	99	148	180	130	113
	0.77	0.57	0.70	0.85	1.04			0.78	1.12	1.05	0.91	0.67
ijssoepje	140	140	124	137	159	181	—	—	171	166	—	146
	0.98	1.05	0.82	1.00	1.17	1.23			1.52	1.13		0.82

Table B.4: Results of the degemination word pairs of the production experiment in Zwolle, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11	12
stee-grachtje	129	91	123	96	131	123	—	92	112	147	93	102
	0.76	0.64	0.82	0.67	0.94	0.96		0.76	0.82	1.03	0.87	0.60
droog grachtje	114	109	127	132	168	162	170	120	117	154	132	146
	0.80	0.83	0.90	1.30	1.60	1.10	1.22	1.13	1.00	0.85	1.15	1.25
lagaatje	130	93	131	—	151	154	112	121	143	—	122	130
	1.02	1.07	0.94		2.04	2.07	1.47	0.73	1.05		0.99	0.99
laaggaatje	161	92	96	176	156	171	—	—	228	192	142	168
	1.15	1.08	0.69	1.20	1.56	1.54			1.98	1.29	1.14	1.06
veegebied	116	111	92	82	120	109	75	86	112	98	92	82
	0.92	0.84	0.64	0.61	0.95	0.65	0.56	0.57	0.74	0.65	0.73	0.48
veeggebied	—	115	120	107	146	189	87	75	—	—	—	94
		1.01	0.94	0.78	1.03	1.28	0.54	0.55				0.53
steeman	98	74	88	75	95	141	86	90	100	89	80	73
	0.74	0.53	0.61	0.55	0.79	1.20	0.92	0.70	0.79	0.62	0.69	0.49
systeemman	122	89	94	107	90	165	112	106	114	108	86	85
	0.95	0.84	0.71	0.78	0.80	1.45	0.73	0.78	0.86	0.71	0.79	0.62
rijmeester	91	78	86	89	82	110	66	84	91	90	144	78
	0.72	0.61	0.67	0.64	0.55	0.80	0.47	0.56	0.68	0.53	0.85	0.52
rijmmeester	138	165	88	92	93	127	92	105	114	120	163	87
	1.20	1.15	0.64	0.71	0.67	0.80	0.69	0.69	0.61	0.75	1.27	0.69
meinummer	89	56	55	65	75	140	59	93	64	120	69	66
	0.68	0.42	0.30	0.44	0.47	0.99	0.41	0.72	0.53	0.78	0.50	0.42
mijn nummer	100	72	56	74	61	171	71	68	79	113	96	106
	1.20	0.92	0.54	0.72	0.59	1.21	0.66	0.75	0.71	1.28	1.03	0.95
zijnetje	81	43	54	47	65	110	55	58	63	83	68	54
	0.46	0.31	0.31	0.29	0.45	0.53	0.40	0.35	0.39	0.52	0.39	0.33
zijn netje	111	79	79	73	72	142	72	85	83	98	—	83
	1.06	0.79	0.68	0.70	0.78	1.09	0.57	0.76	0.74	0.84		0.64
koeluchtje	72	68	—	72	84	99	—	71	130	48	80	77
	0.59	0.87		0.77	1.03	0.76		1.02	1.25	0.60	0.60	0.85
koelluchtje	138	78	108	127	69	—	134	88	100	148	45	93
	1.59	1.21	1.15	1.51	0.56		1.02	0.90	1.22	1.62	0.37	1.35
zijlatje	75	68	62	69	58	85	66	43	69	69	53	56
	0.50	0.42	0.45	0.43	0.41	0.55	0.44	0.28	0.39	0.50	0.38	0.33

Table B.4: Results of the degemination word pairs of the production experiment in Zwolle, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11	12
zeillatje	107	169	75	118	142	110	59	66	77	196	54	71
	0.55	1.59	0.39	0.81	1.03	0.72	0.39	0.41	0.53	1.79	0.31	0.51
ja-regeling	84	55	60	36	55	43	54	43	68	87	41	50
	0.57	0.37	0.36	0.26	0.39	0.24	0.40	0.29	0.42	0.52	0.36	0.37
jaarregeling	65	54	51	46	54	86	82	48	65	81	53	50
	0.38	0.46	0.34	0.28	0.43	0.63	0.70	0.35	0.52	0.66	0.41	0.43
meereizen	42	27	51	45	—	47	63	40	53	41	44	50
	0.26	0.18	0.29	0.27		0.30	0.46	0.30	0.35	0.21	0.27	0.32
meerreizen	121	34	139	82	66	92	60	37	60	—	41	60
	0.81	0.21	0.86	0.60	0.47	0.52	0.38	0.25	0.37		0.27	0.36
strojasje	95	53	59	87	69	91	82	70	71	58	61	77
	0.83	0.36	0.54	0.86	0.51	0.67	0.66	0.43	0.50	0.40	0.49	0.52
strooijasje	88	80	66	95	87	94	106	72	118	102	99	82
	0.72	0.72	0.48	0.69	0.73	0.63	1.03	0.48	0.74	0.76	0.67	0.52
strojongen	110	68	78	71	105	95	101	86	114	112	57	91
	0.82	0.44	0.58	0.62	0.97	0.69	0.74	0.51	1.04	0.75	0.50	0.89
strooijongen	—	99	100	98	79	200	101	107	115	102	99	64
		0.90	0.70	0.85	0.66	1.49	0.94	0.87	0.88	0.80	1.01	0.44
showwaarzegger	84	92	80	87	68	96	69	81	—	81	54	71
	0.55	0.65	0.55	0.63	0.42	0.61	0.44	0.54		0.49	0.29	0.39
macho-waarzegger	71	55	82	81	67	85	92	—	72	63	38	78
	0.66	0.83	0.57	0.93	0.88	0.81	0.72		0.74	0.45	0.50	0.59
zeewater	70	65	67	68	60	75	53	60	66	81	59	56
	0.49	0.49	0.46	0.42	0.36	0.48	0.40	0.40	0.47	0.49	0.49	0.42
Zeeuw-water	158	107	89	88	84	121	112	82	—	128	118	44
	1.92	0.82	0.55	0.61	0.59	1.04	1.03	0.41		0.76	0.91	0.27

B.2 Ambisyllabicity word pairs

The four tables in the remainder of this appendix present all individual measurements of absolute and relative duration of the ambisyllabicity word pairs in the production experiment. Table B.5 reports the measurements from Amsterdam, Table B.6 shows the measurements from Uden, Table B.7 presents this data from Zierikzee, and finally, Table B.8 reports the measurements from Zwolle. Once again, two values are given for each word produced by a participant, the top value represents the absolute duration of the focus consonant in milliseconds, the bottom value represents the relative duration of this consonant compared to the duration of the preceding vowel.

Table B.5: Results of the production experiment in Amsterdam

word	1	2	3	4	5	6	7	8	9	10	11
kapen	111	—	113	120	106	81	119	90	112	132	83
	0.67		0.82	0.81	0.63	0.51	0.88	0.56	0.90	1.05	0.52
kappen	103	126	102	105	100	113	68	105	92	121	85
	1.09	1.87	1.53	1.30	1.21	1.58	0.73	1.62	1.30	2.45	1.10
pieten	108	108	78	98	83	92	146	67	83	118	87
	1.08	1.31	1.08	1.20	1.14	1.00	1.67	0.74	1.23	1.82	1.07
pitten	105	92	62	97	84	61	92	77	107	103	89
	1.26	1.26	0.77	1.49	1.07	0.61	0.93	0.97	1.13	1.40	0.94
roken	76	98	75	—	91	85	86	86	72	104	76
	0.45	0.62	0.43		0.58	0.62	0.56	0.62	0.51	0.82	0.82
rokken	91	104	74	88	86	90	83	51	97	116	71
	0.91	1.05	1.00	1.16	0.96	0.79	0.77	0.52	1.08	1.43	0.55
ramen	95	38	94	58	78	48	75	55	79	72	75
	0.84	0.21	0.52	0.36	0.56	0.42	0.44	0.31	0.48	0.77	0.57
rammen	68	83	84	83	68	79	47	—	88	83	73
	0.67	0.87	1.04	1.03	0.73	0.92	0.41		1.07	1.17	0.93
sparen	44	54	46	38	42	30	35	38	36	40	46
	0.25	0.29	0.29	0.21	0.25	0.22	0.20	0.24	0.25	0.29	0.28
sparren	45	76	86	39	54	65	30	45	36	60	62
	0.42	0.80	1.04	0.41	0.60	0.88	0.38	0.68	0.33	0.62	0.73
sproeien	—	62	75	62	56	53	31	67	67	—	66
		0.60	0.78	0.65	0.87	0.68	0.35	1.22	0.75		0.77
duwen	68	81	96	96	75	67	57	66	87	48	65
	0.65	0.81	0.94	1.09	0.80	0.77	0.60	0.83	0.81	0.38	0.87

Table B.6: Results of the production experiment in Uden

word	1	2	3	4	5	6	7	8	9	10	11	12
kapen	72	113	118	98	122	130	109	103	107	119	155	101
	0.49	0.68	0.75	0.59	0.62	0.95	0.78	0.67	0.60	0.70	0.92	0.53

Table B.6: Results of the production experiment in Uden, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11	12
kappen	84	87	110	108	112	75	84	102	113	114	82	107
	1.17	1.00	1.30	1.22	1.46	1.08	0.72	1.17	1.30	1.25	0.69	1.16
pieten	79	90	98	86	84	92	102	73	106	93	111	89
	1.10	1.52	1.00	1.09	1.25	1.32	1.43	0.94	1.09	0.93	1.13	1.12
pitten	85	90	103	88	87	106	111	102	128	97	118	112
	1.25	1.21	1.01	1.22	1.06	1.52	1.27	1.57	1.87	1.08	1.26	1.34
roken	81	69	80	98	88	107	95	87	104	96	111	102
	0.74	0.41	0.46	0.75	0.57	0.92	0.66	0.51	0.66	0.62	1.10	0.65
rokken	85	99	97	96	98	89	89	81	93	113	115	95
	0.77	1.06	1.01	1.37	0.77	0.86	0.89	0.93	1.01	1.29	1.72	0.81
ramen	63	93	65	84	95	63	65	90	62	86	82	82
	0.47	0.69	0.35	0.62	0.49	0.45	0.49	0.53	0.37	0.55	0.61	0.48
rammen	67	87	82	—	88	61	85	64	79	73	105	80
	0.67	1.03	0.85		0.99	0.63	0.63	0.81	0.98	0.56	1.18	0.66
sparen	73	59	51	51	45	62	55	53	76	52	37	61
	0.43	0.54	0.27	0.24	0.26	0.41	0.34	0.35	0.42	0.33	0.22	0.34
sparren	37	49	56	48	50	43	38	60	58	78	—	59
	0.38	0.48	0.41	0.47	0.62	0.40	0.38	0.66	0.58	0.84		0.50
sproeien	52	93	84	55	63	54	54	59	66	72	76	80
	0.96	0.79	1.26	0.64	0.65	0.67	0.53	1.05	0.82	0.93	1.30	0.91
duwen	58	70	53	40	70	66	63	69	53	64	135	40
	0.63	0.67	0.45	0.30	0.61	0.72	0.57	0.61	0.59	0.81	1.01	0.46

Table B.7: Results of the production experiment in Zierikzee

word	1	2	3	4	5	6	7	8	9	10	11	12
kapen	111	100	78	108	95	115	99	108	113	108	108	—
	0.60	0.67	0.49	0.78	0.62	1.21	0.53	0.56	0.78	0.71	0.79	
kappen	123	94	91	128	101	115	96	103	94	127	127	131
	1.39	1.30	1.46	1.85	1.33	2.28	0.96	1.12	1.19	1.72	1.72	1.79
pieten	114	—	82	106	134	87	117	94	125	119	117	124
	1.59		1.61	1.57	1.98	1.11	1.14	0.82	1.60	1.57	1.55	1.67
pitten	125	119	81	108	121	105	115	83	107	107	121	108
	1.33	1.98	1.56	1.38	1.51	1.42	1.28	0.69	1.24	1.40	1.56	1.36

Table B.7: Results of the production experiment in Zierikzee, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11	12
roken	108	107	—	117	79	95	103	107	87	106	95	112
	0.82	0.92		1.21	0.54	1.15	0.62	0.60	0.64	0.74	0.70	0.77
rokken	99	88	95	92	90	99	105	104	110	101	101	134
	0.87	1.08	1.45	1.39	0.59	1.36	1.03	0.97	1.09	1.36	1.19	1.52
ramen	106	81	57	79	37	88	70	85	94	68	76	87
	0.50	0.78	0.35	0.49	0.25	0.76	0.38	0.57	0.46	0.45	0.50	0.60
rammen	94	54	70	65	68	59	58	84	62	66	90	107
	0.83	0.57	0.69	0.62	0.57	0.77	0.43	0.75	0.62	0.67	0.87	1.16
sparen	121	41	46	38	36	42	50	63	88	50	53	19
	0.60	0.21	0.32	0.16	0.24	0.27	0.26	0.30	0.48	0.28	0.31	0.11
sparren	50	44	24	39	63	45	51	67	66	36	49	23
	0.38	0.36	0.28	0.30	0.69	0.61	0.41	0.50	0.64	0.42	0.47	0.21
sproeien	74	65	94	81	41	45	96	65	81	71	98	73
	0.80	0.81	1.62	0.90	0.47	0.62	0.79	0.94	0.73	0.79	1.00	0.82
duwen	69	82	54	92	53	66	91	94	55	—	88	104
	0.60	0.67	0.57	0.95	0.55	0.66	0.79	0.78	0.52		0.83	1.06

Table B.8: Results of the production experiment in Zwolle

word	1	2	3	4	5	6	7	8	9	10	11	12
kapen	115	118	110	113	107	97	109	74	123	131	101	113
	0.78	0.80	0.66	1.51	0.63	0.68	0.89	0.53	0.77	0.79	0.98	0.88
kappen	105	109	114	113	103	111	123	87	122	119	94	—
	1.32	1.43	1.26	1.57	1.45	1.64	1.60	1.30	1.86	1.97	1.58	
pieten	97	94	98	101	112	104	125	109	104	101	78	106
	1.13	1.27	1.45	1.57	1.70	1.38	2.24	2.37	1.64	1.46	1.05	1.62
pitten	138	110	105	102	106	122	119	100	88	98	88	111
	1.90	2.27	1.46	1.68	1.85	1.72	1.47	1.34	1.56	1.58	1.59	1.43
roken	91	102	103	101	90	87	107	76	104	137	101	106
	0.83	0.65	0.69	0.86	0.70	0.50	0.85	0.55	0.74	0.88	0.83	0.86
rokken	92	95	92	97	91	107	—	84	107	97	90	110
	0.91	1.23	0.79	1.78	1.31	0.91		0.96	1.02	1.09	1.08	1.09
ramen	82	78	82	80	79	86	71	70	97	87	75	77
	0.71	0.57	0.70	0.53	0.45	0.46	0.47	0.39	0.82	0.50	0.51	0.71

Table B.8: Results of the production experiment in Zwolle, *Continued*

word	1	2	3	4	5	6	7	8	9	10	11	12
rammen	90	74	91	75	71	107	84	64	82	82	78	65
	1.23	0.99	0.83	1.13	0.90	1.04	0.75	0.87	0.77	0.88	0.98	0.71
sparen	65	26	52	47	51	72	36	39	56	32	33	40
	0.40	0.16	0.30	0.30	0.35	0.35	0.22	0.23	0.29	0.18	0.20	0.25
sparren	40	32	47	31	54	58	54	35	62	58	78	65
	0.40	0.38	0.40	0.29	0.61	0.49	0.65	0.38	0.67	0.54	1.00	0.83
sproeien	77	74	102	78	89	115	78	70	74	85	74	106
	1.04	1.10	0.99	0.88	1.19	1.40	1.25	1.10	1.11	1.12	1.24	2.26
duwen	103	62	84	58	89	90	89	81	63	92	52	78
	1.37	0.82	0.98	0.80	1.23	0.69	0.89	0.98	0.64	0.79	0.57	1.13

Appendix C. Results perception experiment

The following pages will provide the reader with the identification scores for every individual fragment. The tables are ordered in the following way: we first present the results of the fragments that came from minimal pairs with differences between single and double consonants similar to the overall difference. Then, we present the results from the fragments taken from pairs (almost) without any difference between single and double consonants. Both tables start with the plosive fragments, followed by fricative, nasals, liquids and glides. For each word, two values are given: the upper value is the number of incorrect identifications, the lower value is the number of correct identifications. In Table C.2, some pairs were not included in the experiment, because the average difference between single and double plosives was already very low. These pairs are indicated by n.s., meaning ‘not selected’.

C.1 Minimal pairs with a difference between single and double consonants

Table C.1: Number of incorrect and correct identifications for the fragments with a difference between single and double consonants

word		Uden	Zierikzee	Zwolle	Total
kruipaaltje	incorrect	1	3	5	9
	correct	6	5	3	14
kruippaaltje	incorrect	0	6	2	8
	correct	1	1	5	7
stropotje	incorrect	1	3	0	4
	correct	6	8	1	15

Table C.1: Number of incorrect and correct identifications for the fragments with a difference between single and double consonants, *Continued*

word		Uden	Zierikzee	Zwolle	Total
strooppotje	incorrect	1	0	5	6
	correct	6	0	6	12
bijteentje	incorrect	4	3	2	9
	correct	5	10	0	15
bijt-teentje	incorrect	10	1	8	19
	correct	3	0	0	3
meeturen	incorrect	4	1	1	6
	correct	5	6	0	11
meet-turen	incorrect	10	1	11	22
	correct	4	0	3	7
pi-koorts	incorrect	4	1	1	6
	correct	8	7	6	21
piekkoorts	incorrect	0	12	6	18
	correct	0	2	5	7
diefestivals	incorrect	1	1	3	5
	correct	0	7	5	12
G-frequentie	incorrect	1	7	1	9
	correct	7	7	0	14
geeffrequentie	incorrect	4	4	2	10
	correct	4	4	5	13
zee-franje	incorrect	1	4	1	6
	correct	0	8	7	15
zeef-franje	incorrect	0	9	6	15
	correct	0	3	1	4
eisapje	incorrect	0	1	1	2
	correct	0	6	11	17
ijssapje	incorrect	8	5	8	21
	correct	5	2	2	9
kruis-teken	incorrect	1	1	2	4
	correct	13	6	5	24
kruis-steken	incorrect	10	4	9	23
	correct	3	4	3	10

Table C.1: Number of incorrect and correct identifications for the fragments with a difference between single and double consonants, *Continued*

word		Uden	Zierikzee	Zwolle	Total
lagaatje	incorrect	0	0	0	0
	correct	0	7	1	8
laaggaatje	incorrect	3	5	1	9
	correct	9	3	1	13
veegebied	incorrect	2	1	1	4
	correct	5	6	0	11
veeggebied	incorrect	5	0	9	14
	correct	7	0	5	12
rijmeester	incorrect	4	2	2	8
	correct	10	11	6	27
rijmmeester	incorrect	0	10	5	15
	correct	2	2	5	9
meinummer	incorrect	3	1	0	4
	correct	4	6	1	11
mijnnummer	incorrect	8	3	0	11
	correct	5	8	1	14
zijnetje	incorrect	1	1	2	4
	correct	10	0	11	21
zijnnetje	incorrect	0	9	7	16
	correct	1	5	4	10
koeluchtje	incorrect	8	1	0	9
	correct	0	0	1	1
koelluchtje	incorrect	0	4	0	4
	correct	0	8	12	20
zijlatje	incorrect	2	2	4	8
	correct	9	9	8	26
zeillatje	incorrect	1	9	1	11
	correct	11	1	6	18
ja-regeling	incorrect	3	1	7	11
	correct	8	0	7	15
jaarregeling	incorrect	0	1	4	5
	correct	0	0	8	8

Table C.1: Number of incorrect and correct identifications for the fragments with a difference between single and double consonants, *Continued*

word		Uden	Zierikzee	Zwolle	Total
meereizen	incorrect	0	4	1	5
	correct	7	21	11	39
meerreizen	incorrect	11	11	4	26
	correct	1	0	4	5
strojasje	incorrect	2	1	0	3
	correct	6	6	1	13
strooijasje	incorrect	4	2	2	8
	correct	22	10	10	42
strojongen	incorrect	5	0	0	5
	correct	8	7	0	15
strooijongen	incorrect	0	2	0	2
	correct	0	10	0	10
zeewater	incorrect	0	0	0	0
	correct	7	8	8	23
Zeeuw-water	incorrect	2	0	1	3
	correct	11	10	13	34

C.2 Minimal pairs without a difference between single and double consonants

Table C.2: Number of incorrect and correct identifications for the fragments without a difference between single and double consonants. n.s. = not selected

word		Uden	Zierikzee	Zwolle	Total
kruipaaltje	incorrect	2	3	6	11
	correct	6	4	4	14
kruippaaltje	incorrect	0	7	5	12
	correct	0	8	3	11
stropotje	incorrect	0	2	4	6
	correct	0	6	4	10
strooppotje	incorrect	8	6	4	18
	correct	6	2	3	11

Table C.2: Number of incorrect and correct identifications for the fragments without a difference between single and double consonants, *Continued*

word		Uden	Zierikzee	Zwolle	Total
bijteentje	incorrect	0	7	1	8
	correct	1	3	6	10
bijt-teentje	incorrect	7	1	12	20
	correct	1	0	2	3
meeturen	incorrect	n.s.	n.s.	0	0
	correct			0	0
meet-turen	incorrect	n.s.	n.s.	0	0
	correct			0	0
pi-koorts	incorrect	3	3	0	6
	correct	8	9	7	24
piekkoorts	incorrect	11	10	7	28
	correct	3	3	4	10
diefestivals	incorrect	1	4	0	5
	correct	6	10	1	17
G-frequentie	incorrect	n.s.	1	2	3
	correct		0	7	7
geeffrequentie	incorrect	n.s.	6	11	17
	correct		5	3	8
zee-franje	incorrect	4	4	n.s.	8
	correct	4	5		9
zeef-franje	incorrect	0	0	n.s.	0
	correct	1	2		3
eisapje	incorrect	n.s.	4	n.s.	4
	correct		8		8
ijssapje	incorrect	n.s.	0	n.s.	0
	correct		0		0
kruis-teken	incorrect	4	1	4	9
	correct	7	0	8	15
kruis-steken	incorrect	0	1	11	12
	correct	0	1	2	3
lagaatje	incorrect	9	9	1	19
	correct	3	4	7	14

Table C.2: Number of incorrect and correct identifications for the fragments without a difference between single and double consonants, *Continued*

word		Uden	Zierikzee	Zwolle	Total
laaggaatje	incorrect	3	3	7	13
	correct	10	9	0	19
veegebied	incorrect	6	0	3	9
	correct	5	7	7	19
veeggebied	incorrect	1	7	7	15
	correct	0	1	5	6
rijmeester	incorrect	0	2	0	2
	correct	8	6	0	14
rijmmeester	incorrect	7	4	11	22
	correct	0	4	1	5
meinummer	incorrect	2	3	0	5
	correct	5	7	1	13
mijnnummer	incorrect	7	3	4	14
	correct	1	10	5	16
zijnetje	incorrect	1	0	1	2
	correct	7	7	7	21
zijnnetje	incorrect	5	2	7	14
	correct	7	6	1	14
koeluchtje	incorrect	3	n.s.	0	3
	correct	8		0	8
koelluchtje	incorrect	7	n.s.	9	16
	correct	0		3	3
zijlatje	incorrect	2	n.s.	4	6
	correct	12		9	21
zeillatje	incorrect	1	n.s.	0	1
	correct	0		8	8
meereizen	incorrect	n.s.	n.s.	1	1
	correct			13	13
meerreizen	incorrect	n.s.	n.s.	12	12
	correct			0	0
strojasje	incorrect	0	0	3	3
	correct	0	0	6	6

Table C.2: Number of incorrect and correct identifications for the fragments without a difference between single and double consonants, *Continued*

word		Uden	Zierikzee	Zwolle	Total
strooijasje	incorrect	2	3	0	5
	correct	6	10	1	17
strojongen	incorrect	1	0	4	5
	correct	0	0	10	10
strooijongen	incorrect	1	0	7	8
	correct	11	0	5	16
zeewater	incorrect	4	2	0	6
	correct	7	12	1	20
Zeeuw-water	incorrect	2	7	7	16
	correct	10	0	1	11