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The internally layered foot in Dutch

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Abstract: Recent metrical studies have proposed that, under certain circumstances, a weak syllable may be adjoined to a binary foot, giving rise to a minimally recursive foot. Adding to a growing body of research from metrical stress and foot-conditioned phenomena in various languages, the goals of this paper are twofold. First, we aim at providing empirical evidence for internally layered feet based on the distribution of three foot-conditioned processes of Dutch: vowel reduction, glottal stop /ʔ/ insertion and /h/ licensing/deletion. Second, we explore a less studied theoretical and descriptive advantage of internally layered feet: their potential to predict phonological strength distinctions that go beyond the traditional weak vs. strong dichotomy. In support of this view, we will argue that all three above-mentioned foot-based processes of Dutch distinguish between two types of unstressed syllables. We will demonstrate that the metrical representation that best captures this dual patterning of unstressed syllables necessitates internally layered feet.

Keywords: Dutch, metrical phonology, layered feet, vowel reduction, initial strengthening

1 Introduction

In metrical theory and prosodic hierarchy theory, the category "foot" has traditionally been assumed to be: (i) maximally disyllabic and (ii) universally immediately dominated by the prosodic word (e.g., Nespor and Vogel 1986; McCarthy and Prince 1996 [1986]; Hayes 1995) (throughout the paper, headedness is indicated with vertical lines, parentheses signal foot boundaries and "σ" denotes syllables):

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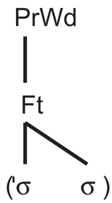
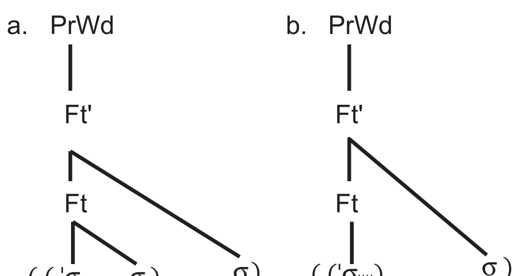
(1) Traditional assumptions about foot structure



However, recent metrical studies have challenged both assumptions. In particular, it has been proposed that, under certain circumstances, a weak syllable may be adjoined to a binary foot, giving rise to a *minimally recursive* foot; in these structures, a foot dominates another foot (Davis 1999, 2005; Jensen 2000; Davis and Cho 2003; Yu 2004; Bennett 2012, 2013; Kager 2012; Martínez-Paricio 2012, 2013; Martínez-Paricio and Kager 2015; Buckley 2014; Breteler 2015). For instance, in Martínez-Paricio (2013) and Martínez-Paricio and Kager (2015) metrical model, feet are maximally trisyllabic, consisting of a disyllabic foot and an adjoined weak syllable (2a). In this model, a layered foot can also consist of a monosyllabic bimoraic foot plus an adjoined syllable (2b). As we will see below, this latter structure occurs in some quantity-sensitive languages.

(2) Minimal recursion at the foot level: internally layered (IL) feet



Metrical representations such as those in (2) or similar ones were already proposed in seminal studies on foot structure in the early eighties (Selkirk 1980; Prince 1980) and have since occasionally been invoked in the analysis of particular languages (see, for example, McCarthy 1982; Grijzenhout 1990; Hewitt 1992; Rice 1992; Kager 1994; van der Hulst 2010). Still, it was not until recently that a number of studies have advanced typological and representational arguments aiming at their rehabilitation in metrical theory.

On the typological side, it was argued that reference to IL feet facilitates an account of the binary-to-ternary rhythmic continuum in metrical stress systems (Martínez-Paricio and Kager 2015). Moreover, postulating IL feet enables a restrictive account of the maximal size of stress and accentual windows (see Kager 2012, based on Caballero 2008; cf. Hyde 2015). Beyond the typology of stress patterns, it has been argued that the IL foot is necessary to explain cases of foot-conditioned phonotactics and tonotactics in languages from a variety of linguistic families (see references above).

Adding to this growing body of research, the goals of this paper are twofold. On the one hand, we aim at providing empirical evidence for IL feet based on the distribution of three foot-conditioned processes of Dutch: vowel reduction, glottal stop /ʔ/ insertion and /h/ licensing/deletion. In a more general vein, it is our goal to explore a less studied theoretical and descriptive advantage of IL feet: their potential to predict phonological strength distinctions that go beyond the traditional weak *vs*. strong dichotomy (Martínez-Paricio 2013). In support of this view, we will argue that all three above-mentioned foot-based processes of Dutch distinguish between two types of unstressed syllables. In the course of the article we will demonstrate that the metrical representation that best captures this dual patterning of unstressed syllables necessitates IL feet.

Crucial to our analysis will be the hypothesis that the beginning of a prosodic category and, in particular, the beginning of a foot (layered or not) is a prominent position that can be targeted by strengthening effects. This idea was already present in the analysis of several phonological distributions in other languages (see Kiparsky 1979; Withgott 1982; Jensen 2000; Davis and Cho 2003; Davis 2005; Harris 2013 on English; and Leer 1985; Rice 1992 on Chugach Alutiiq). It has been significantly reinforced in recent work by Bennett (2012, 2013), who demonstrated that even in iambic languages, foot-initial weak syllables (e.g., (σ̲ ˈσ)) may undergo strengthening effects due to the greater relative prominence associated with prosodic-initial domains.

The organization of the paper is as follows. We start by illustrating the dual patterning of unstressed syllables in Dutch vowel reduction (Section 2) and introduce the metrical model of Martínez-Paricio and Kager (2015), serving as the theoretical framework for our analysis of Dutch foot-conditioned processes (Section 3). In Section 4, we discuss Davis and Cho (2003) and Davis' (2005) analysis of the distribution of aspirated stops and /h/ in English, which makes use of IL feet and inspired our analysis of Dutch.

Section 5 constitutes the analytic core of the article: it contains an analysis of Dutch stress in terms of IL feet (Section 5.1) while providing independent evidence for our metrical analysis based on an examination of three foot-conditioned phenomena: vowel reduction (Section 5.2), glottal stop /ʔ/ insertion (Section 5.3) and /h/ licensing/deletion (Section 5.4). In Section 6, we briefly summarize and disregard alternative representational analyses and we conclude in Section 7.

2 The puzzle: the duality of unstressed vowels in Dutch vowel reduction

Dutch vowel reduction (i.e., the phonetic realization of underlying full vowels as schwa, henceforth VR) is one of the most studied phenomena in Dutch phonology (e.g., Booij 1981, 1982; Kager 1989; van Oostendorp 1995; Geerts 2008; Nazarov 2009). The process is conditioned by several factors, including register of speech (VR being more frequent in informal registers than formal and semiformal registers) and vowel quality: not all vowels show reduction potential to the same extent, but some of them are more prone to reduce than others (for the specific vowel reduction hierarchy, see Kager 1989; Booij 1995; Nazarov 2009).[1]

The current paper does not contain new data on Dutch VR, neither does it provide a comprehensive account of all the factors that condition it (e.g., lexical, morphological, phonological, pragmatic). It concentrates instead on disentangling a single well-known but puzzling phonological aspect of the process: the dual behavior of identical vowels in unstressed syllables. This duality is illustrated below in (3). The generalization is that in a sequence of two stressless syllables with identical vowels, sitting between an initial secondary stress and the primary stress (i.e., the underlined sequence in [ˌσ $\underline{\sigma_2}$ $\underline{\sigma_3}$ ˈσ...]), as in *ˌloc**<u>o</u>**m**<u>o</u>**'tief* 'locomotive', *ˌind**<u>i</u>**v**<u>i</u>**'du* 'individual' or *ˌec**<u>o</u>**n**<u>o</u>**'mie* 'economy', the reduction of the vowel in the third syllable implies the reduction of the vowel in the second syllable, i.e., the forms in (3d) are

1 According to Kager (1989: 303), this hierachy is: e > a > o, ø > i > u, y, starting from the most reducible vowel to the least reducible. Nazarov (2009) has also corroborated this generalization recently. Booij (1995: 134) presents a slightly different hierarchy, in which /ø/ is placed among the least reducible vowels /u, y/, while lax vowels /ɪ, ɑ, ɔ/ are also included. Phonetic (corpus-based) studies of reducibility as it depends on vowel quality include Ernestus (2000), Kloots (2008), and Coussé et al. (2007).

unattested in every register. The data in (3) shows that in formal register, both identical unstressed vowels keep their underlying quality specification (3a); in semi-formal register, only the posttonic vowel following the secondary stress reduces (3b), while in informal register, vowel reduction targets both stressless vowels. Crucially, forms in which the unstressed vowel in the pretonic syllable preceding the primary stress reduces, but the unstressed vowel in the posttonic syllable does not, are not attested in any register.

(3) Different VR patterns of identical vowels in different unstressed syllables

	a. Formal	b. Semi-formal	c. Informal	d. Unattested
locomotief	[ˌlo.k**o**.m**o**.'tif]	[ˌlo.k**ə**.m**o**.'tif]	[ˌlo.k**ə**.m**ə**.'tif]	*[ˌlo.k**o**.m**ə**.'tif]
economie	[ˌe.k**o**.n**o**.'mi]	[ˌe.k**ə**.n**o**.'mi]	[ˌe.k**ə**.n**ə**.'mi]	*[ˌe.k**o**.n**ə**.'mi]
reparateur	[ˌre.p**a**.r**a**.'tør]	[ˌre.p**ə**.r**a**.'tør]	[ˌre.p**ə**.r**ə**.'tør]	*[ˌre.p**a**.r**ə**.'tør]
declaratief	[ˌde.kl**a**.r**a**.'tif]	[ˌde.kl**ə**.r**a**.'tif]	[ˌde.kl**ə**.r**ə**.'tif]	*[ˌde.kl**a**.r**ə**.'tif]
individu	[ˌɪn.d**i**.v**i**.'dy]	[ˌɪn.d**ə**.v**i**.'dy]	[ˌɪn.d**ə**.v**ə**.'dy]	*[ˌɪn.d**i**.v**ə**.'dy]
specificeer	[ˌspe.s**i**.f**i**.'ser]	[ˌspe.s**ə**.f**i**.'ser]	[ˌspe.s**ə**.f**ə**.'ser]	*[ˌspe.s**i**.f**ə**.'ser]

This observation led scholars to the conclusion that Dutch medial unstressed syllables display two degrees of *strength* (Booij 1977, 1981; Kager 1989; van Oostendorp 1995). For instance, van Oostendorp (1995: 113) distinguished between unstressed syllables that are *weak* (i.e., σ_2 in 3) and hence, more eager to undergo VR, as opposed to *semi-weak* syllables (i.e., σ_3 in 3), which block VR in some contexts (3b, 3d), maintaining the underlying specification of the vowels. (See also Crosswhite and McDonough 2000, who report two types of unstressed syllables in Russian based on vowel reduction patterns.)

Importantly, this subtle subdivision of unstressed syllables is attested across identical structural positions. Kager (1989: 312) observed that not only vowels in posttonic syllables in the above-mentioned context (i.e., [ˌσ_1 σ_2 σ_3 'σ...]) reduce in informal and semi-formal registers, but posttonic syllables in different contexts such as a pretonic syllable in [ˌσ_1 σ_2 'σ_3 σ...] have similar reduction potential in non-formal registers. Hence, both positions can be characterized as *weak*. This is illustrated in (4), where it can be seen that all vowels in posttonic position undergo reduction in non-formal registers, no matter they appear in a non-pretonic (4a) or a pretonic position (4b).

(4) Weak position: VR in semi-formal and informal registers

<table>
<tr><th>POSTTONIC σ</th><th>Formal</th><th>Semi-formal</th><th>Informal</th></tr>
<tr><td>a. Non-pretonic</td><td>[ˌlo.ko$_2$. mo. ˈtif]
‘locomotive’</td><td>[ˌlo.kə$_2$. mo. ˈtif]</td><td>[ˌlo.kə$_2$. mə. ˈtif]</td></tr>
<tr><td>b. Pretonic</td><td>[ˌlo.ko$_2$. ˈmo.tsi]
‘locomotion’
[ˌfo.no$_2$.ˈloχ]
‘phonologist’
[ˌe.ko$_2$. ˈnom]
‘economist’</td><td colspan="2">[ˌlo.kə$_2$. ˈmo.tsi]

[ˌfo.nə$_2$.ˈloχ]

[ˌe.kə$_2$.ˈnom]</td></tr>
</table>

Similarly, the pretonic non-posttonic third syllable in [ˌσ_1 σ_2 σ_3 ˈσ...] is not the only unstressed syllable which behaves as *semi-weak*; other syllables in structurally identical positions behave analogously. In particular, vowels located in pretonic but non-posttonic position in an initial unstressed syllable, [σ_1 ˈσ...], such as ***to'maat*** 'tomato' and *ko'nijn* 'rabbit', only reduce to schwa in informal register. Furthermore, specific words such as *mo'tief* 'motive' even resist VR in this register.[2] [2] In sum, these facts evidence the greater relative strength of semi-weak syllables (σ_1 and σ_3) as opposed to weak ones in (4) (σ_2).

(5) Semi-weak position: VR only in informal register (with some lexical exceptions such as [**mo$_1$**.ˈtif] in which the initial syllable does not undergo VR even in informal registers)

PRETONIC, BUT NON-POSTTONIC σ	Formal	Semi-formal	Informal
a. Medial	[ˌlo.ko. **mo$_3$**.ˈtif] ‘locomotive’	[ˌlo.kə. **mo$_3$**.ˈtif]	[ˌlo.kə. **mə$_3$**.ˈtif]
b. Initial	[**to$_1$**. ˈmat] ‘tomato’ [**ko$_1$**.ˈnɛin] ‘rabbit’ [**mo$_1$**.ˈtif] ‘motive’	[**to$_1$**. ˈmat] [**ko$_1$**.ˈnɛin] [**mo$_1$**.ˈtif]	[**tə$_1$**. ˈmat] [**kə$_1$**.ˈnɛin] [**mo$_1$**.ˈtif]

2 In ultra-informal registers, VR is marginally attested in such words. For instance, the initial unstressed syllable in *motief* 'motive' undergoes VR in some speakers in ultra-informal register, e.g., [mə$_1$.ˈtif].

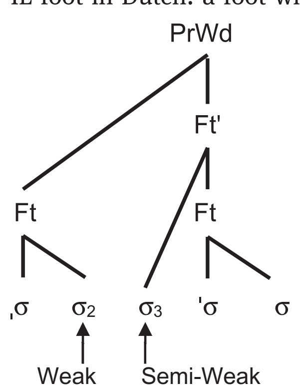
An empirically accurate and theoretically adequate analysis of Dutch VR should offer an explanation of why some unstressed syllables are phonologically *stronger* than others. Likewise, it should be able to capture all the similarities and dissimilarities between unstressed syllables described in this section. For ease of exposition, these are summarized in the following table.

(6) Generalizations in Dutch VR

A. Dissimilarity between *weak* (σ_2) and *semi-weak* positions (σ_1,σ_3):		
[ˌlo. **ko**$_2$. mo. ˈtif]	≠	[ˌlo. ko. **mo**$_3$. ˈtif]
(posttonic)		(non-posttonic)
⇒ The former reduce in more registers than the latter		
B. Similarity between σ_2 (posttonic) *weak* positions:		
[ˌlo. **ko**$_2$. mo. ˈtif]	=	[ˌlo. **ko**$_2$. ˈmo. tsi]
(non-posttonic)		(pretonic)
⇒ VR in semi-formal and informal registers		
C. Similarity between σ_1 and σ_3 (pretonic) *semi-weak* positions:		
[ˌlo. kə. **mo**$_3$. ˈtif]	=	[mo$_1$. **ˈtif**]
(medial)		(initial)
⇒ VR only in informal registers, with some lexical exceptions in which the initial syllable does not undergo VR even in informal registers		

In Section 5, we will argue that the most appropriate representation to capture these facts is an IL foot with a left adjunct (7). In this representation, unstressed syllables are all in foot-dependent positions but some of them are stronger than others given their particular location within a foot. More specifically, following Bennett (2012, 2013), we will argue that the *foot-initial* domain is a privileged position in prosody (e.g., σ_3 in 7), which can either be protected from undergoing weakening processes such as VR, or it can be the target of strengthening effects.

(7) IL foot in Dutch: a foot with a left adjunct



Here we will demonstrate that this type of IL foot accounts not only for the dual behaviour of unstressed syllables in VR, but also for the distribution of some consonants in Dutch. In particular, we will argue that the glottal fricative /h/ (Section 5.3) and the glottal stop /ʔ/ (Section 5.4) are only licensed as onsets of specific unstressed syllables, crucially those that coincide with the left edge of a foot, IL or not. In unstressed syllables in other metrical positions, these consonants are dispreferred. Furthermore, in Section 6 it will be shown that alternative representational models without IL feet, which have attempted to account for the duality of unstressed syllables (i) by referring to the difference between weak *unfooted* and *footed* syllables, or (ii) by using IL feet with alternative shapes (e.g., an IL foot with a right adjunct), fail to provide a unified explanation of these metrically-conditioned processes in Dutch.

In the next two sections we start by outlining the main assumptions of the theoretical model in which our analysis of Dutch foot-conditioned phonotactics is couched (Section 3) by summarizing Davis and Cho (2003) and Davis' (2005) metrical account of the distribution of aspirated and unaspirated stops and /h/ in English (Section 4), which will serve as a background for our own interpretation of the Dutch facts in Section 5.

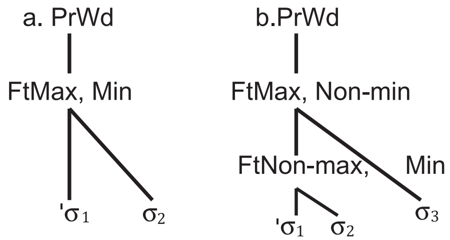
3 Theoretical framework: a metrical model with IL feet

In our analysis of Dutch stress and foot-conditioned phonotactics in Section 5, we adopt the metrical model of Martínez-Paricio (2013) and Martínez-Paricio and Kager (2015). On the representational side, this model allows foot structure to be recursive, but only minimally so: a single foot layer can be stacked on top of a binary foot by adjunction, as indicated in (2). To differentiate between different types of foot projections, this model expands the notation employed by Itô and Mester's theory of prosodic recursion (2007, 2009a, 2009b, 2013) to the level of the foot. According to this proposal, each projection of the foot can be defined as *minimal* (or *non-minimal*) and *maximal* (or *non-maximal*) based on its particular dominance relations. The definitions of (non-)minimal/(non-)maximal feet are given in (8) and they are illustrated in (9).

(8) Projections of a metrical foot Ft (based on Itô and Mester 2007 *et seq.*)

a.	Maximal:	Ft not dominated by Ft	The largest projection of Ft
b.	Minimal:	Ft not dominating Ft	The smallest projection of Ft
c.	Non-maximal:	Ft dominated by Ft	
d.	Non-minimal:	Ft dominating Ft	

(9)



The terms *minimal/maximal* and *non-minimal/non-maximal* do not refer to primitive categories in the prosodic hierarchy, but are merely structural labels that can be fully and locally inferred from domination relations; namely, from a foot's daughter node (i.e., whether a foot immediately dominates another foot or not) and a foot's mother node (i.e., whether a foot is immediately dominated by another foot or not). Since a traditional bisyllabic foot is dominated by the prosodic word and does not dominate a foot, it will be characterized as *maximal* and *minimal* (9a). By contrast, the innermost constituent in an IL foot (9b) is *non-maximal* because it is directly dominated by a foot, while the topmost foot projection in (9b) is *non-minimal* and *maximal*, given that it dominates another foot, but is itself dominated by the prosodic word. Note that the emergence of a minimally recursive foot is not completely unexpected from the point of view of current approaches to Prosodic Hierarchy Theory, in which some degree of recursion is permitted.

Furthermore, these distinctions between foot projections have been shown to be crucial to modeling the typology of binary and ternary rhythmic stress (see Martínez-Paricio and Kager 2015), as well as to explaining the particular behavior of different metrically governed phenomena (Martínez-Paricio 2013). In these works the reader can find stress and non-stress evidence for all types of IL feet (trochees with a left or right adjunct, iambs with a left or right adjunct).[3] In Section 5 it will be argued that these distinctions are also crucial in the analysis of Dutch stress and the metrically-governed phenomena examined in this article.

As the grammatical framework, Martínez-Paricio and Kager (2015) adopt Optimality Theory (Prince and Smolensky 2004 [1993]). They postulate a small set of categorical alignment constraints of the non-intervention type, which

3 Besides evidence for the right-branching amphibrach (σ (σ 'σ)) as discussed in the current paper, there is typological evidence for the right-branching anapest (σ (σ 'σ)) (Caballero 2008), as well as for both types of left-branching IL feet: The dactyl (('σ σ) σ) and left-branching amphibrach ((σ 'σ) σ) (Kager 2012; Martínez-Paricio 2013; Bennett 2013; among others).

regulate the location and type of feet for quantity-insensitive systems. In Section 5.1 it will be shown how interactions of this set of constraints, with a few additions, can account for the quantity-sensitive stress system of Dutch too.

In addition to these violable constraints, Martínez-Paricio and Kager assume that the rhythmic nature of the foot imposes three hard restrictions which limit the types of feet generated by *Gen*. First, it is assumed that recursion at the foot level is always restricted to one level, as opposed to recursion at higher layers of the prosodic hierarchy, where recursion is generally assumed to be unlimited. Note that supra-foot categories (prosodic word, phonological phrase, etc.) are externally defined with respect to syntax, which is a recursive system, and hence, intrinsically involve multiple layers of recursion (Itô and Mester 2007 *et seq*.). In contrast, no external system forces unlimited foot recursion, e.g., (...((('σ σ)$_{Ft}$ σ)$_{Ft}$ σ)$_{Ft}$ σ)$_{Ft}$ ...)$_{Ft}$. On typological grounds, minimal recursion is motivated by the observation that languages with ternary rhythm are attested, but no languages with quaternary or longer rhythms. Second, the foot's rhythmic nature forces its recursion to be *unbalanced* (Vigario 2010), that is, a minimally recursive foot results from adjoining a weak syllable to a foot, e.g., (('σ σ)$_{Ft}$ σ)$_{Ft}$. *Balanced* recursive structures, in which a foot dominates two feet, are ruled out, e.g., *(('σ σ)$_{Ft}$ ('σ σ)$_{Ft}$)$_{Ft,}$ *(('σ σ)$_{Ft}$ ('σ)$_{Ft}$)$_{Ft}$, as they defeat the rhythmic definition of a foot, requiring the foot to have one unique head. Third, it is assumed that IL feet are necessarily branching, ruling out vacuous recursion, e.g., * (('σ σ)$_{Ft}$)$_{Ft}$. This assumption, like the previous one, follows from the view that IL feet are formed by adjunction.

Before proceeding to our analysis, it is important to clarify that we do not consider the IL foot to be a prosodic category in its own right, in addition to the traditional foot. Following Nespor and Vogel (1986), Hayes (1995), Itô and Mester (2007, 2009a, 2009b) and other work in Prosodic Hierarchy Theory, we assume prosodic categories to be defined based on particular construction principles – in the case of feet (layered or not) *rhythmic principles, quantity, sonority, relative strength* and *headedness*. Prosodic categories are also defined or singled out by the fact that similar rules or processes target them, e.g., stress, fortition, reduction, etc. By these principles, a layered foot and a "traditional" foot are similar and, for this reason, we believe they should be considered instances of the same category. Note that layered feet do not share defining principles with the prosodic word, the next category in the hierarchy, since this is not exclusively defined based on principles such as rhythm, quantity, sonority, relative strength or headedness. Rather, the definition of the prosodic word is partially phonological and partially related to syntax. Moreover, different sets of rules apply at the levels of the prosodic word and foot.

Now that the major theoretical assumptions of this model are clear, we can proceed to our analysis of Dutch. Before that, Section 4 will discuss a case of foot-dependent segment distribution from English, which is a striking counterpart to the Dutch case.

4 The IL foot in English

Davis and Cho (2003) and Davis (2005) observed that English aspirated stops $[p^h, t^h, k^h]$ and [h] display a parallel distribution and crucially, they demonstrated that this can be directly accounted for by making reference to IL feet. Their proposal was based on previous analyses of the distribution of aspirated stops in English (Withgott 1982; Jensen 2000), however they take it one step further, by unifying the account of aspiration and /h/ licensing/deletion. As illustrated in the following examples, aspirated stops $[p^h, t^h, k^h]$ and [h] appear in the onset of stressed syllables (10.I,II) and unstressed pretonic syllables, both in word-initial (10.III) and word-medial position (10.IV) (the column on the left displays examples of aspiration, and the column on the right, of /h/ licensing):

(10) Environments of aspiration $[p^h, t^h, k^h]$ and /h/ licensing

I. At the beginning of a syllable with primary stress:

a.	'**p**ony	$[p^h]$	b.	'**h**abit	[h]
	'**t**errible	$[t^h]$		'**h**ero	[h]
	'**c**andy	$[k^h]$		'**h**istory	[h]
	a'**t**omic	$[t^h]$		pro'**h**ibit	[h]
	a'**p**pear	$[p^h]$		Ta'**h**iti	[h]
	ma'**t**erial	$[t^h]$		ma'**h**ogany	[h]
	op'**t**ician	$[t^h]$		ad'**h**erence	[h]

II. At the beginning of a syllable with secondary stress:

a.	'davenˌ**p**ort	$[p^h]$	b.	'alcoˌ**h**ol	[h]
	Aˌ**t**asca'dero	$[t^h]$		Aˌ**h**asu'erus	[h]
	ˌ**t**i'tanic	$[t^h]$		ˌ**h**y'potenuse	[h]
	'cuˌ**c**umber	$[k^h]$		'Idaˌ**h**o	[h]

III. At the beginning of a word-initial stressless syllable:

a.	**P**a'cific	$[p^h]$	b.	**h**o'rizon	[h]
	to'mato	$[t^h]$		**H**a'waii	[h]
	co'nnect	$[k^h]$		**h**a'bitual	[h]
	po'tato	$[p^h]$		**h**y'pocrisy	[h]

IV. At the beginning of a stressless syllable when immediately preceded by a stressless syllable and followed by a stressed one:

a.	ˌMedi**t**e'rranean	[t^h]	b.	Tara**h**u'mara	[h]
	ˌNavra**t**i'lova	[t^h]			
	ˌlola**p**a'looza	[p^h]			
	ˌWine**p**e'ssaukee	[p^h]			
	ˌperi**p**a'tetic	[p^h]			
	ˌNebu**c**ad'nezzar	[k^h]			
	abra**c**a'dabra	[k^h]			

In other contexts, the fricative /h/ may undergo deletion and the lenis variants of the aspirated stops surface instead, i.e., [p, t, k]. In particular, [h] and [p^h, t^h, k^h] are banned in codas (11.I), in the onset of posttonic syllables (11.II), and in the second member of an onset (11.III).

(11) Environments where neither aspiration nor /h/ surface

I. In coda position (ħ indicates a possible /h/ that does not surface)

a.	at.las	[t˺]	b.	Teħ.ran	[ħ]
	ac.ne	[k˺]		braħ.min	[ħ]
	hyp.no.sis	[p˺]		Yaħ.weħ	[ħ]
	lapse	[p˺]		Faħd	[ħ]

II. At the beginning of a (noninitial) stressless syllable following a stressed one

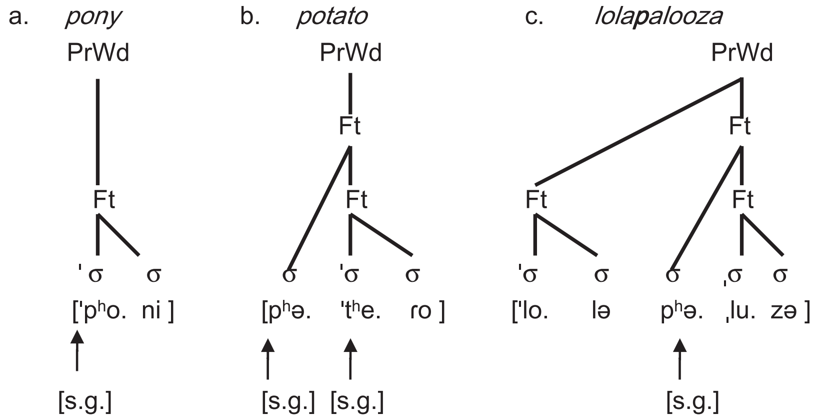
a.	'atom	[ɾ]	b.	've.ħi.cle	[ħ]
	'Mickey	[k]		ˌpro.ħi.'bi.tion	[ħ]
	'rapid	[p]		'ni.ħi.lism	[ħ]
	'happen	[p]		ˌpre.ħi.'sto.ric	[ħ]

III. As a possible second member of an onset

a.	'ski	[k]	b.	Bħutan	[ħ]
	expo'sition	[p]		exħi'bition	[ħ]
	e[k's]tinguish	[t]		ex'ħibit	[ħ]

What is puzzling in these data, similarly to the Dutch data outlined in Section 2, is the dual patterning of unstressed syllables: whereas pretonic syllables behave like tonic syllables – these license aspiration and /h/ (10.III, IV) – posttonic ones don't (11.II). Interestingly, Davis and Cho (2003), based on Jensen (2000), offer a straightforward explanation for this duality, which resorts to IL feet and the greater relative prominence of segments in foot-initial positions. Elaborating on earlier ideas on the distribution of aspirated stops in English (Kiparsky 1979; McCarthy 1982; Withgott 1982; Jensen 2000), Davis and Cho propose that just as strengthening processes may target initial elements in higher-order prosodic categories (e.g., prosodic word, phonological phrase), the feature [spread glottis] – which they assume is shared by aspirated consonants and /h/ (Iverson and Salmons 1995) – is inserted in foot-initial positions as a means of strengthening the left boundary of a foot. Davis and Cho (2003: 615) follow Iverson and Salmons (1995) in the interpretation that the feature [spread glottis] "makes for a more forceful sound given the greater translaryngeal air flow that occurs with the articulation of a sound made with spread glottis". The realization of this feature is perceptually salient and, hence, it can be used to indicate a prominent position (Davis and Cho 2003: 615). Adopting Jensen's idea that pretonic unstressed syllables are adjoined to a following trochaic foot, which results in an IL foot, e.g., (σ (ˈσ σ)), it becomes clear why aspirated stops and /h/ are only licensed in the onset of pretonic and tonic syllables: these positions coincide with the left edge of a foot.[4] In (12) we illustrate this with concrete examples. Note that stressed syllables (12a), as well as word-initial and word-medial pretonic syllables (12b,c), all display aspiration and are all located at the left edge of a foot.

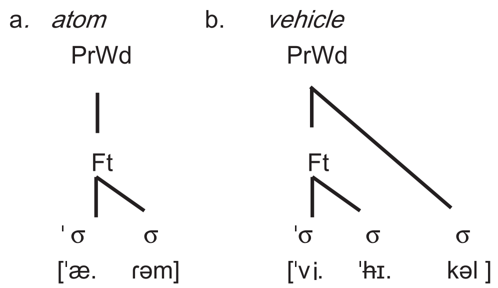
(12) Foot-initial strengthening: insertion of [spread glottis] (abbr. [s.g.])



4 Jensen's (2000: 210) argument literally runs as follows, "Withgott indeed claims that a light syllable is adjoined to the right, but does not adequately formalize adjunction. Therefore, she has to state aspiration as a disjunction: 'stops are aspirated when they begin a foot, and when they begin the stressed syllable of a foot' (1982: 161). This disjunction is unnecessary if adjunction is stated as Chomsky Adjunction".

Davis and Cho (2003) show that, similarly, this metrical analysis with IL feet accounts for the emergence of /h/ in the onset of particular syllables: the feature [spread glottis] is inserted only foot-initially: e.g., (ˈ**h**æ.bɪt) *habit*, (**h**ə.(ˈray.zɪn)) *horizon*, (ˌtæ.rə)(**h**u.(ˈmæ.rə)) *Tarahumara*. In contrast, the feature is not licensed in foot-final and foot-medial position, where the *lenis* non-aspirated stops [p, k] and the flap [ɾ] occur, while /h/ is deleted.

(13) Unaspirated stops and /h/ deletion



This analysis unifies the contexts in which stops are aspirated and /h/ is licensed, while capturing the underlying motivation for their prosodic distribution. In Section 5, we will extend Jensen's (2000) and Davis and Cho (2003) metrical approach to Dutch, and demonstrate that English is not the only Germanic language in displaying foot-initial strengthening effects.

In our analysis of Dutch foot-initial strengthenings, we adopt Jensen's and Davis and Cho's adjoined foot structures, however our original contribution will be in deriving these structures from an explicitly stated metrical grammar which accounts for the Dutch stress distribution (as shown in Section 5.1) and which is based on principled constraints which have proven their typological validity (Martínez-Paricio and Kager 2015). Also, our analysis has the virtue of unifying several foot-governed process of Dutch, viz. vowel reduction, /h/-deletion and glottal insertion.

5 The IL foot in Dutch

5.1 Dutch stress: OT metrical analysis

We assume the following generalizations for Dutch stress, drawing on earlier descriptive work (e.g., van der Hulst 1984; Kager 1989; van Oostendorp 1995;

Gussenhoven 1993; Gussenhoven 2009; among others). Some sub-patterns and lexical exceptions occur, which we will not discuss (see references above).

Primary stress is penultimate ([a.'χa:.ta] 'Agatha'; [a.'mɑn.da] 'Amanda'), except in two cases: (a) in words of three or more syllables, primary stress is on the antepenult in case the penult is open and the final is closed (['ma:.ra.ˌtɔn] 'marathon'; ['ɑl.ma.ˌnɑk] 'almanac'; [be.'ɛl.zə.ˌbœp] 'Beelzebub'); (b) primary stress is on the final if it is "superheavy" (CV:C or CVCC) ([to.'ma:t] 'tomato'; [ˌle.di.'kɑnt] 'bed').

Secondary stresses fall on alternating syllables preceding the primary stress, going from left to right while avoiding clash ([ˌo.no.ˌma.to.'pe:] 'onomatopoeia'; [ˌlo.ko.mo.'tif] 'locomotive'; [ˌmo.ti.'ve:r] 'motivate'; [to.'ma:t] 'tomato']). However, in case the second syllable in a sequence of syllables before the primary stress is heavy and/or 'cyclically' stressed, this syllable, rather than the initial, attracts secondary stress ([ka.ˌlɛi.dɔs.'ko:p] 'caleidoscope'; [ko.ˌlo.ni.'a:l] 'colonial'; [ko.ˌlo.ni.a.'lɪst] 'colonialist'). A secondary stress also falls on the final syllable in case primary stress falls on the antepenult (['ma:.ra.ˌtɔn] 'marathon'; ['ɑl.ma.ˌnɑk] 'almanac'). Long-voweled and closed syllables are bimoraic and heavy; however note that vowel duration in the non-high tense vowels (/a, e, o, ø/) strictly depends on stress: these are predictably long in primary stressed syllables, and short elsewhere (van Oostendorp 1995; Gussenhoven 2009). Vowel duration will not be transcribed in examples below.

An analysis of Dutch word stress in the IL metrical foot framework runs as follows. We adopt the quantity-sensitive trochee from Gussenhoven (2009) as the FtMin. This respects the WEIGHT-TO-STRESS-PRINCIPLE (WSP: Heavy syllables must be stressed; Prince 1983), the STRESS-TO-WEIGHT-PRINCIPLE (SWP: Stressed syllables must be heavy; Prince 1990), and FOOT-BINARITY (FTBIN: Feet must be binary on syllabic or moraic analysis; Prince 1980), rendering FtMin minimally bimoraic and maximally bisyllabic. Monosyllabic FtMin is a bimoraic syllable containing either a phonetically long vowel[5] or a short vowel plus coda. Next, the IL foot arises by adjoining a single syllable at the left edge of FtMin. Hence, the Dutch foot is a trochaic FtMin with an optional initial adjunct, which has four shapes:

(14)	a.i	FtMin = σσ	('σ σ)	default shape, positionally unrestricted
	a.ii	FtMin = σσ, IL	(σ ('σ σ))	marked shape, mostly in final position
	b.ii	FtMin = μμ	('$\sigma_{\mu\mu}$)	limited to final position (Gussenhoven 1993)
	b.ii	FtMin = μμ, IL	(σ ('$\sigma_{\mu\mu}$))	marked shape, limited to final position

5 FtMin = μμ need not hold absolutely, in light of phonetically short lax vowels in stressed open syllables, e.g., *zie* ('zi) 'zie', *magie* (ma.('χi)) 'magic', *alibi* ('a.li).(ˌbi) (idem).

The Dutch IL foot has a somewhat restricted distribution, occurring almost exclusively in word-final position, and obligatorily so in case of (σ (ˈ$\sigma_{\mu\mu}$)). As explained in Section 3, the IL foot is a derived category – this is precisely why in Dutch it only occurs in specific contexts (word-finally), the default foot shape being a binary trochee. Metrical structures of sequences of light syllables before the primary stress are shown in (15).

(15)	a.i	(σ (ˈσ σ))	(ko.(ˈlo.ni))	'colony'
			(mo.(ˈdy.lə))	'module'
	a.ii	(σ (ˈ$\sigma_{\mu\mu}$))	(mo.(ˈtif))	'motive'
			(to.(ˈmat))	'tomato'
	b.i	(ˌσ σ) (ˈσ σ)	(ˌmo.no).(ˈpo.li)	'monopoly'
			(ˌlo.ko).(ˈmot.si)	'locomotion'
	b.ii	(ˌσ σ) (ˈ$\sigma_{\mu\mu}$)	(ˌmo.ti).(ˈver)	'motivate'
			(ˌfo.no).(ˈloχ)	'phonologist'
	c.i	(ˌσ σ) (σ (ˈσ σ))	(ˌe.ko).(no.(ˈmɪs.mə))	'economism'
			(ˌa.bra).(ka.(ˈda.bra))	'abracadabra'
	c.ii	(ˌσ σ) (σ (ˈ$\sigma_{\mu\mu}$))	(ˌlo.ko).(mo.(ˈtif))	'locomotive'
			(ˌfo.no).(lo.(ˈχi))	'phonology'
	d.i	(ˌσ σ) (ˌσ σ) (ˈσ σ)	(ˌa.ro).(ˌma.ti).(ˈsat.si)	'aromatization'
			(ˌmo.no).(ˌpo.lo).(ˈi.də)	'monopoloid'
	d.ii	(ˌσ σ) (ˌσ σ) (ˈ$\sigma_{\mu\mu}$)	(ˌo.no).(ˌma.to).(ˈpe)	'onomatopoeia'
			(ˌfo.no).(ˌlo.χi).(ˈser)	'phonologize'

In case the second syllable in a sequence of syllables before the primary stress is heavy and/or cyclically stressed (Kager 1989), we find a word-initial IL foot (16):

(16)	a.	(σ (ˌσ σ)) (ˈ$\sigma_{\mu\mu}$)	(ka.(ˌlɛi.dɔs)).(ˈkop)	'caleidoscope'
			(e.(ˌlɛk.tri)).(ˈser)	'electrify'
			(ko.(ˌlo.ni)).(ˈal)	'colonial'
	b.	(σ (ˌσ σ)) (σ (ˈ$\sigma_{\mu\mu}$))	(e.(ˌlɛk.tri)).(si.(ˈtɛit))	'electricity'
			(ka.(ˌrɑk.tə)).(rɪs.(ˈtik))	'characteristic'
			(ko.(ˌlo.ni)).(a.(ˈlɪst))	'colonialist'

These are actually the only cases in which the Dutch IL foot (σ (ˈσ σ)) may occur in non-final position. (Compare light syllable sequences containing no cyclic stresses in (15c)–(15d)

Gussenhoven (1993) convincingly shows (using evidence from the melodic pattern of the 'chanted call') that antepenultimate primary stress is always accompanied by a final secondary stress ([ˈɑl.ma.ˌnɑk] ‘almanac’, not [ˈɑl.ma.nɑk]). This observation immediately follows from the IL foot analysis on the assumption that metrification must be *exhaustive*. IL feet have initial adjuncts and hence no dactylic feet ((ˈσ σ) σ) are ever allowed.[6] Hence antepenultimate stress can only arise when a disyllabic primary stress foot is followed by a monosyllabic secondary stress foot: [(ˈɑl.ma).(ˌnɑk)].

Turning to an OT analysis, we capture generalizations on foot distribution by a set of categorical alignment constraints, stated in the non-intervention format (McCarthy 2003; Martínez-Paricio and Kager 2015). Three constraints are undominated:

(17) a. ALIGN-R-($[\text{Ftunary}]_\omega$, *Ft, ω) (abbr. ALIGN-Runary)
“For every Ftunary_i, assign a violation mark if some foot intervenes between Ftunary_i and the right edge of its containing prosodic word.”

b. ALIGN-R-($[\sigma]_\omega$, *Ft, ω) (abbr.CHAIN-R)
“For every unfooted syllable $[\sigma_i]_\omega$ assign a violation mark if some foot intervenes between $[\sigma_i]_\omega$ and the right edge of its containing prosodic word.”

c. ALIGN-R-($[\text{Ftprimary}]_\omega$, *Ftbranching, ω) (LCPR; Liberman and Prince 1977)[7]
“For every Ftprimary_i, assign a violation mark if a branching foot occurs between Ftprimary_i and the right edge of its containing prosodic word.”

Example (17a) correctly predicts that a unary FtMin can only occur in final position, and (17b) that an unparsed syllable (if it occurs at all, see Footnote 4), can only occur in final position. Finally, (17c) predicts that the rightmost foot is strong if it branches. This constraint set is sufficient to derive the Dutch trisyllabic window (Kager 1989; Gussenhoven 1993, 2009). In order to represent pre-antepenultimate stress while using only licit

6 The single exception to exhaustive metrification are words ending in a schwa in hiatus, e.g., *ˈweduwe* ‘widow’ (Kager and Zonneveld 1986; Kager 1989), which we assume to be metrified as follows: [(ˈʋe.dy).ə].

7 This constraint functions to place the primary stress on a branching foot in final position, and to retract the primary stress onto the prefinal foot in case the final foot is not branching. Its function is similar to the Lexical Category Prominence Rule (LCPR): Given a pair of nodes $[N_1\ N_2]$, N_2 is s *iff* it branches (Liberman and Prince 1977).

shapes of the Dutch IL foot, some undominated alignment constraint needs to be violated:

(18)
a. (ˈ**σ** σ) (ˌσ$_{\mu\mu}$) (ˌσ$_{\mu\mu}$) # violates (17a)
b. (ˈ**σ** σ) ə (ˌσ$_{\mu\mu}$) # violates (17b)
c. (ˈ**σ** σ) (ˌσ σ) # violates (17c)
d. (ˈ**σ** σ) (σ (ˌσ$_{\mu\mu}$))# violates (17c)

The only case of pre-antepenultimate stress predicted to occur is (ˈ**σ** σ) (ˌσ) ə #, which is in fact attested (e.g., *ˈAmeˌrongen* (ˈa.mə).(ˌrɔŋ).ə, *ˈWageˌningen* (ˈʋa.χə)(ˌnɪŋ).ə).

The distribution of the four foot shapes is summarized below, together with the constraints responsible for excluding the gaps.

(19) Overview of foot shapes

	single foot	initial primary	initial secondary	final primary	final secondary
(ˈσ σ)	(ˈ**mo.tsi)**	(ˈ**ɑl.ma).**(ˌnɑk)	**(ˌlo.ko).**(ˈmo.tsi)	(ˌlo.ko).(ˈ**mo.tsi)**	17c
(σ (ˈσ σ))	**(ko.(ˈlo.ni))**	**(be.(ˈɛl.zə)).**(ˌbœp)	**(ko.(ˌlo.ni)).**(ˈal)	(ˌa.bra).**(ka.(ˈda.bra))**	17c
(ˈσ$_{\mu\mu}$)	(ˈ**ver)**	17a	17a	(ˌmo.ti).(ˈ**ver)**	(ˈɑl.ma).**(ˌnɑk)**
(σ (ˈσ$_{\mu\mu}$))	**(mo.(ˈtif))**	17a	17a	(ˌlo.ko).**(mo.(ˈtif))**	17c

The distribution of secondary stress feet can be appreciated best in terms of optimal and suboptimal structures. All comparisons involve candidates with fixed primary stress (e.g., final stress in *onomatopee*); also, all candidates are exhaustively parsed into licit IL feet.

(20) a. Non-IL feet are preferred to IL feet
(ˌo.no).(ˌma.to).(ˈpe) > **(o.(ˌno.ma)).(to.(ˈpe))**
(ˌmo.ti).(ˈver) > (ˌmo).**(ti.(ˈver))**
b. Final IL feet are preferred to non-final IL feet
(ˌlo.ko).(mo.(ˈtif)) > **(lo.(ˌko.mo)).**(ˈtif)
(ˌa.bra).(ka.(ˈda.bra)) > **(a.(ˌbra.ka)).**(ˈda.bra)
c. Stress faithfulness and/or WSP may override these preferences
(e.(ˌlɛk.tri)).(ˈser) > (ˌe.**lɛk**).(tri.(ˈser))
(e.(ˌlɛk.tri)).(si.(ˈtɛit)) > (ˌe.**lɛk**).(ˌtri.si).(ˈtɛit)

d. Yet even here, non-IL feet are preferred to IL feet
(e.(ˌlɛk.tri)).(ˈser) > (e.(ˌlɛk)).**(tri.(ˈser))**
(e.(ˌlɛk.tri)).(si.(ˈtɛit)) > (e.(ˌlɛk)).(ˌtri.si).(ˈtɛit)[8]

To capture these preferences, we need two more non-intervention constraints, pulling IL feet to the right and left edge, respectively (Martínez-Paricio and Kager 2015):

(21) a. ALIGN-R-([Ftnon-min]$_{\omega}$, *Ft, ω) (abbr. ALIGN-NONMIN-R)
"For every Ftnon-min$_i$ assign a violation mark if some foot intervenes between Ftnon-min$_i$ and the *right* edge of its containing prosodic word"
b. ALIGN-L-([Ftnon-min]$_{\omega}$, *Ft, ω) (abbr. ALIGN-NONMIN-L)
"For every Ftnon-min$_i$ assign a violation mark if some foot intervenes between Ftnon-min$_i$ and the *left* edge of its containing prosodic word"

By ranking ALIGN-NONMIN-R above ALIGN-NONMIN-L, the canonical position for an IL foot is final, not initial. Still, the lower-ranked constraint may become active to minimize the number of IL feet. The interactions between constraints are shown in the tableaux below:

(22)

	WSP	ALIGN-NONMIN-R	ALIGN-NONMIN-L
☞a. (ˌo.no).(ˌma.to).(ˈpe)			
b. (o.(ˌno.ma)).(to.(ˈpe))		*!	*

(23)

	WSP	ALIGN-NONMIN-R	ALIGN-NONMIN-L
☞a. (ˌlo.ko).(mo.(ˈtif))			*
b. (lo.(ˌko.mo)).(ˈtif)		*!	

(24)

	WSP	ALIGN-NONMIN-R	ALIGN-NONMIN-L
☞a. (e.(ˌlɛk.tri)).(ˈser)		*	
b. (e.(ˌlɛk)).(tri.(ˈser))		*	*!
c. (ˌe.lɛk).(tri.(ˈser))	*!		*

8 Based on the first author's observation, both metrical patterns for *elektriciteit* seem to be attested.

Note how IL feet are generally pulled to the right edge by ALIGN-NONMIN-R (22a), (23a), except when an initial IL foot is forced by higher-ranked WSP (blocking (24c)). In that case ALIGN-NONMIN-L steps in to minimize the number of IL feet, preferring binary feet (25a).

This leads to the following conclusions on Dutch stress distribution. First, stress patterns of Dutch words are all analyzable as exhaustive metrifications by licit expansions of the IL foot. Second, restrictions on IL foot distribution are captured by typologically motivated constraints. We now proceed to show that the IL foot straightforwardly accounts for three metrically conditioned segmental processes of Dutch viz. vowel reduction (Section 5.2), glottal stop insertion (Section 5.3), and /h/-deletion/licensing (Section 5.4).

5.2 Vowel reduction

In Section 2 we saw that unstressed syllables in Dutch display two degrees of strength with respect to vowel reduction. Namely, weak syllables located in a pretonic non-posttonic position are characterized as *semi-weak*, slightly stronger than genuinely *weak* syllables occurring in a posttonic position, since the latter undergo VR in more registers than the former. An accurate analysis of Dutch VR should offer an explanation of these degrees of phonological strength among unstressed syllables and capture the structural similarities and dissimilarities between unstressed syllables described in Section 2. For ease of exposition, these are summarized again in the following table.

(25) Generalizations in Dutch VR

A.	Dissimilarity between *weak* (σ_2) and *semi-weak* positions (σ_1,σ_3):		
	[ˌlo.**kə**$_2$. mo. ˈtif] (posttonic)	≠	[ˌlo.ko. **mo**$_3$. ˈtif] (non-posttonic)
	⇒ The former reduce in more registers than the latter		
B.	Similarity between σ_2 (posttonic) *weak* positions:		
	[ˌlo.**kə**$_2$. mo.ˈtif] (non-posttonic)	=	[ˌlo.**kə**$_2$. ˈmo.tsi] (pretonic)
	⇒ VR in semi-formal and informal registers		
C.	Similarity between σ_1 and σ_3 (pretonic) *semi-weak* positions:		
	[ˌlo.kə. **mo**$_3$. ˈtif] (medial)	=	[**mo**$_1$. ˈtif] (initial)
	⇒ VR only in informal registers, with some lexical exceptions in which the initial syllable does not undergo VR even in informal registers		

If we adopt the metrical parsings of Dutch provided in Section 5.1, it becomes clear why vowels in unstressed syllables differ in their degree of reducibility. Just as in English the foot-initial domain is a privileged position which is targeted by strengthening processes such as aspiration, our proposal is that the foot-initial domain is similarly a prominent position in Dutch and, hence, vowels in the first syllable of a foot can be protected from undergoing reduction, even if unstressed.

Generally, the weak nature of unstressed syllables makes them good loci for lenition processes such as vowel reduction. Yet when unstressed syllables appear foot-initially in Dutch, their vowels preserve their underlying quality in most formal and even in some informal registers. In particular, as can be observed in (26)–(28), unstressed vowels located in a foot-initial position only reduce in the informal register (26b), (26c); furthermore, in specific words like *motif* 'motive', reduction does not even apply in this register (26d). In contrast, a vowel occurring in a foot-dependent position that is not foot-initial undergoes reduction in both informal and semiformal registers (26a), (27a). In the formal register (28), the metrical status of a vowel becomes irrelevant: all vowels are preserved no matter their position in the word or their degree of prominence.

(26) Informal register: VR in every dependent of a foot, initially and finally

a.	(ˌlo.kə$_2$). (mə$_3$. (ˈtif))	σ$_2$ Ft final	*Reduction*
b.	(ˌlo.kə$_2$). (mə$_3$. (ˈtif))	σ$_3$ Ft initial	*Reduction*
c.	(tə$_1$. (ˈmat))	σ$_1$ Ft initial	*Reduction*
d.	(mo$_1$. (ˈtif))	σ$_1$ Ft initial	Lexical exceptions to reduction[9]

(27) Semi-formal register: VR in the dependent of a foot, only if it is in final position

a.	(ˌlo.kə$_2$). (mo$_3$. (ˈtif))	σ$_2$ Ft final	*Reduction*
b.	(ˌlo.kə$_2$). (mo$_3$. (ˈtif))	σ$_3$ Ft initial	No reduction
c.	(to$_1$. (ˈmat))	σ$_1$ Ft initial	No reduction
d.	(mo$_1$. (ˈtif))	σ$_1$ Ft initial	No reduction

(28) Formal register: lack of vowel reduction in unstressed syllables

a.	(ˌlo.ko$_2$). (mo$_3$. (ˈtif))	σ$_2$ Ft final	No reduction
b.	(ˌlo.ko$_2$). (mo$_3$. (ˈtif))	σ$_3$ Ft initial	No reduction
c.	(to$_1$. (ˈmat))	σ$_1$ Ft initial	No reduction
d.	(mo$_1$. (ˈtif))	σ$_1$ Ft initial	No reduction

9 These words may display reduction in superinformal registers.

The metrical parsings in (26)–(28) demonstrate that the greater prominence associated with the left edge of a foot favors the preservation of vowel quality in foot-initial syllables, even if unstressed.

An OT implementation of the dual patterning of weak syllables with respect to VR in Dutch can be provided using positional faithfulness constraints (Beckman 1998). The cross-linguistic observation that segments in the head of a prosodic constituent are preserved to a greater extent than segments in a non-head domain has lead scholars to propose positional faithfulness constraints preserving feature specifications specifically in prosodic heads (e.g., HEAD-IDENT[FEATURE]; McCarthy 1995; Alderete 1995, 1999; Beckman 1998). The concrete definition of the positional faithfulness constraint on foot-heads is given below:

(29) FOOTHEAD-IDENT[FEATURE] (abbr. FTHD-IDENT[F]) (from Alderete 1999)
Correspondent segments contained in a foot head must be identical for F.
If β is contained in a prosodic head in S2, and αRβ, then α and β agree in the feature F

Since vowel reduction never applies to stressed syllables, FTHD-IDENT[F] must be high-ranked in Dutch. More specifically, this constraint must dominate the markedness constraint that favors reduction (i.e., a context free constraint against particular features of full vowels), as well as the general faithfulness constraint that preserves feature identity in input and outputs, i.e., IDENT[F]. The interaction of these constraints is illustrated in (30). This tableau contains the evaluation of the form /fonoloχ/, which in informal and semi-formal registers displays reduction of the second /o/, e.g., [ˌfo.nə.'loχ]. The particular markedness constraint that enforces reduction in this tableau is *[O], which bans mid back vowels. Since most of our examples involve /o/, it suffices to present the interaction of *[O] with faithfulness constraints. However, since the reduction potential of Dutch vowels depends on their quality as well as on their metrical position, a small set of vowel-specific markedness constraints will be assumed, which interact with faithfulness constraints to predict the reducibility hierarchy of vowel qualities (Kager 1989). For reasons of conciseness, we will not discuss the full set of markedness constraints and their interactions with faithfulness constraints here.

Since we have already provided the rankings responsible for the location of stress in Dutch (Section 5.1), for the sake of simplicity, the following tableaux contain only candidates that obey the high-ranked constraints on stress, and differ only in application of VR.

(30) Informal and Semi-formal register: /fonoloχ/ → [ˌfonə'loχ].

/fonoloχ/	FTHD-IDENT[F]	*[O]	IDENT[F]
☞ a. (ˌfo.**nə**).('loχ)		**	*
b. (ˌfo.no).('loχ)		***!	
c. (ˌ**fə**.**nə**).('**lə**χ)	*!*		***
d. (ˌ**fə**.no).('loχ)	*!	**	*

Undominated HEAD-IDENT[F] ensures that vowel reduction is blocked in metrically strong positions, which explains why candidates with reduction of stressed vowels are ruled out (30c, d). The ranking *[O] > > IDENT[F] favors reduction and prioritizes candidate (30a) over (30b). The reverse ranking IDENT[F] > > *[O], illustrated below in (31), preserves all underlying vocalic features, corresponding to the pattern reported in formal registers.

(31) Formal register: /fonoloχ/ → [ˌfono'loχ].

/fonoloχ/	FTHD-IDENT[F]	IDENT[F]	*[O]
a. (ˌfo.**nə**).('loχ)		*!	**
b. (ˌ**fə**.**nə**).('**lə**χ)	*!*	***	
c. (ˌ**fə**.no).('loχ)	*!	*	**
☞ d. (ˌfo.no).('loχ)			***

Until here, the Dutch patterns are fairly common. What makes Dutch special is the dual patterning of unstressed syllables, with a subset of them blocking reduction foot-initially. To account for the greater strength of unstressed syllables foot-initially, we propose another positional faithfulness constraint, which preserves features in the foot-initial domain.

(32) INITIALFOOT-IDENT[FEATURE] (abbr. INITIALFT-IDENT[F])
Segments contained in the first syllable of a foot in an output must be identical for F with their correspondent segments in the input. If β is contained in the foot initial syllable in S2, and αRβ, then α and β agree in the feature F.

This constraint is well-grounded in prosodic phonology since the initial position of syllables, prosodic words and higher categories in the prosodic hierarchy have been reported to be *privileged* in the sense that they can be protected from undergoing weakening processes and/or they can become the target of strengthening effects (e.g., Trubetzkoy 1969 [1939]; Steriade 1994; Byrd 1996; Beckman 1998; Casali 1998; Alber 2001; Smith 2005; Cabré and Prieto 2006; Becker et al. 2012; Fougeron and Keating 1997; Keating et al. 2003; Selkirk 2011). To capture the dual patterning of unstressed vowels in Dutch and, more specifically, the fact that in the semi-formal register not all unstressed vowels reduce (e.g., [ˌlok**ə**moˈtif], rather than [ˌlokəməˈtif]), we propose that the positional constraint in (32), together with the previous positional constraint on foot heads, outrank *[O] and IDENT[F], as shown in the following tableau:

(33) Semi-formal register /lokomotif/ → [ˌlok**ə**moˈtif]

/lokomotif/	FTHD-IDENT[F]	INITIALFT-IDENT[F]	*[O]	IDENT[F]
☞ a. (ˌlo.k**ə**).(mo.(ˈtif))			**	*
b. (ˌlo.k**ə**).(m**ə**.(ˈtif))		*!	*	**
c. (ˌlo.ko).(m**ə**.(ˈtif))		*!	**	*
d. (ˌl**ə**.ko).(mo.(ˈtif))	*	*!	**	*
e. (ˌlo.ko).(mo.(ˈtif))			***!	

The ranking FTHD-IDENT[F], INITIALFT-IDENT[F] >>*[O] >>IDENT[F] correctly accounts for the dual behavior of weak syllables in the semi-formal register. On the one hand, FTHD-IDENT[F] bans candidates with reduced vowels on stressed syllables (cf. 33d) and INITIALFT-IDENT[F] ensures that vowels in the first syllable of a foot preserve their underlying feature specification; this is why candidates (33b) and (33c) are sub-optimal. On the other hand, by ranking *[O] above the general faithfulness constraint IDENT[F], it is predicted that reduction takes place only in unstressed syllables that do not occur foot-initially: (33a) is selected over (33b). The reverse ranking would produce forms without reduction, attested in formal registers. Finally, to account for the reduction patterns in informal registers, where reduction applies indiscriminately to all unstressed vowels, we just need to rank the markedness constraint *[O] above the positional faithfulness constraint INITIALFT-IDENT[F]. This ensures that candidate (34b) surfaces as optimal:

(34) Informal register /lokomotif/ → [ˌlokəmə'tif]

/lokomotif/	HEAD-IDENT[F]	*[O]	INITIALFT-IDENT[F]	IDENT[F]
a. (ˌlo.kə).(mo.('tif))		**!		*
☞ b. (ˌlo.kə).(mə.('tif))		*	*	**
c. (ˌlo.ko).(mə.('tif))		**!	*	*
d. (ˌlə.ko).(mo.('tif))	*!	**	*	*
e. (ˌlo.ko).(mo.('tif))		**!*		

5.3 Licensing and deletion of the glottal fricative [h] in Dutch

Further data corroborating the strength dichotomy among Dutch unstressed syllables comes from the distributional pattern of the glottal fricative [h]. This segment is optionally deleted in the onset of some syllables, but obligatorily retained in the onset of others.

First, as observed by Gussenhoven (1993), /h/ is obligatorily retained in the onset of stressed syllables, either with primary or secondary stress. This is illustrated in (35)–(38). As shown in the third column of these examples, the beginning of a stressed syllable coincides with the beginning of a foot.

(35) Onset of initial primary stress: /h/-deletion is blocked

a.	haar	['**h**ar]	('**h**ar)	'hair'
b.	hoop	['**h**op]	('**h**op)	'hope'
c.	hoed	['**h**ut]	('**h**ut)	'hat'
d.	halo	['**h**a.lo]	('**h**a.lo)	'halo'
e.	honing	['**h**o.nɪŋ]	('**h**o.nɪŋ)	'honey'
f.	hoeve	['**h**u.və]	('**h**u.və)	'farm'

(36) Onset of non-initial primary stress: /h/-deletion is blocked

a.	cohort	[ko.'**h**ɔrt]	(ko.('**h**ɔrt))	(idem)
b.	mihun	[mi.'**h**un]	(mi.('**h**un))	'noodles'
c.	poeha	[pu.'**h**a]	(pu.('**h**a))	'give oneself airs'
d.	nihil	[ni.'**h**il]	(ni.('**h**il))	(idem)
e.	jihad	[dʒi.'**h**at]	(dʒi.('**h**at))	(idem)
f.	Sahara	[sa.'**h**a.ra]	(sa.('**h**a.ra))	(idem)
g.	Johannes	[jo.'**h**ɑ.nəs]	(jo.('**h**ɑ.nəs))	'John'
h.	mahonie	[ma.'**h**o.ni]	(ma.('**h**o.ni))	'mahogany'
i.	Almohaden	[ˌɑl.mo.'**h**a.dən]	(ˌɑl.mo).('**h**a.dən)	'Almohades'

(37) Onset of initial secondary stress: /h/-deletion is blocked

a.	hagedis	[ˌ**h**a.χə.ˈdɪs]	(ˌ**h**a.χə).(ˈdɪs)	‘lizard’
b.	harmonie	[ˌ**h**ɑr.mo.ˈni]	(ˌ**h**ɑr.mo).(ˈni)	‘harmony’
c.	homonym	[ˌ**h**o.mo.ˈnim]	(ˌ**h**o.mo).(ˈnim)	‘homonym’

(38) Onset of non-initial secondary stress: /h/-deletion is blocked[10]

a.	Galahad	[ˈχa.la.ˌhɑt]	(ˈχa.la).(ˌ**h**ɑt)	(idem)
b.	Isfahan	[ˈɪs.fa.ˌhɑn]	(ˈɪs.fa).(ˌ**h**ɑn)	(idem)
c.	Kandahar	[ˈkɑn.da.ˌhɑr]	(ˈkɑn.da).(ˌ**h**ɑr)	(idem)
d.	tomahawk	[ˈto.ma.ˌhɔ:k]	(ˈto.ma).(ˌ**h**ɔ:k)	(idem)
e.	Navaho	[ˈna.va.ˌho]	(ˈna.va).(ˌ**h**o)	(idem)
f.	Idaho	[ˈɑj.da.ˌho]	(ˈɑj.da).(ˌ**h**o)	(idem)

Second, [h]-deletion is blocked in the onset of word-initial unstressed syllables (Gussenhoven 1993):

(39) Onset of initial stressless syllable: /h/-deletion is blocked

a.	hotel	[**h**o.ˈtɛl]	(**h**o.(ˈtɛl))	(idem)
b.	hallo	[**h**ɑ.ˈlo]	(**h**ɑ.(ˈlo))	‘hello’
c.	helaas	[**h**e.ˈlas]	(**h**e.(ˈlas))	‘alas’
d.	Homerus	[**h**o.ˈme.rəs]	(**h**o.(ˈme.rəs))	‘Homer’

Our metrical analysis assigns word-initial syllables to foot-initial position. Tentatively, this analysis appears to be further corroborated for word-medial syllables in non-posttonic pretonic (σ_3) position by the data in (40), which we have observed in the speech of some speakers, including the first author of this paper. This specific pattern of /h/-non-deletion, which had not been previously discussed in the literature, was tested by consulting several native speakers, some of whom were able to confirm it for their own speech, while others reported slightly different patterns. Apparently there is some subtle variation among Dutch speakers which is possibly dialect-specific, an issue which needs further investigation. The data in (40) suggest that an analysis of Dutch /h/-licensing/deletion that only appeals to the greater relative strength of the word-initial domain as an explanation for the

10 In a small number of cases, /h/-deletion optionally applies in the onset of a final syllable with secondary stress:

a. alcohol [ˈɑl.ko.ˌ~~**h**~~ɔl] [ˈɑl.kə.ˌɔl] [ˈɑl.kɔl] (idem)
b. Abraham [ˈa.bra.ˌ~~**h**~~ɑm] [ˈa.brə.ˌɑm] [ˈa.brɑm] (idem)
c. Bethlehem [ˈbɛt.le.ˌ~~**h**~~ɛm] [ˈbɛt.lə.ˌʲɛm] [ˈbɛt.lʲɛm] (idem)

All these cases have (near) identical vowels across /h/, and in case /h/-deletion applies, the vowels in hiatus optionally contract.

licensing of /h/ in (39) may be inadequate since deletion of /h/ also appears to be blocked in a specific type of word-medial unstressed syllables occupying the initial position of a word-medial IL foot:

(40) Onset of σ_3: /h/-deletion blocked[11]

a.	Almohadist	[ˌɑl.mo.**h**a.ˈdɪst]	(ˌɑl.mo).(**h**a.(ˈdɪst))	(idem)
b.	Tarahumara	[ˌta.ra.**h**u.ˈma.ra]	(ˌta.ra).(**h**u.(ˈma.ra))	(idem)
c.	Villahermosa	[ˌvi.la.**h**ɛr.ˈmo.sa]	(ˌvi.la).(**h**ɛr.(ˈmo.sa))	(idem)
d.	protohistorisch	[ˌpro.to.**h**ɪs.ˈto.ris]	(ˌpro.to).(**h**ɪs.(ˈto.ris))	‘protohistoric’

Crucially, unstressed syllables in other word-medial positions have been reported in the literature to optionally delete the /h/ of their onsets. Namely, /h/-deletion may apply to posttonic syllables located in a foot-final position. This is the case for foot dependents in the second syllable of a minimal foot, placed either word-finally (41) or word-initially (42). Note that in cases where /h/-deletion applies immediately following a non-low vowel, a transitional glide [ʷ] or [ʲ], homorganic with the preceding vowel qua backness and roundness, is inserted for hiatus resolution (see Gussenhoven 1980 on homorganic glide insertion).

(41) Onset of final σ_2: /h/-deletion applies optionally[12,13]

a.	Johan	[ˈjo.**~~h~~**ɑn]	[ˈjo.ʷɑn]	(ˈjo.**~~h~~**ɑn)	‘John’
b.	sahib	[ˈsa.**~~h~~**ɪp]	[ˈsa.ɪp]	(ˈsa.**~~h~~**ɪp)	(idem)
c.	Aloha	[a.ˈlo.**~~h~~**a]	[a.ˈlo.ʷa]	(a.(ˈlo.**~~h~~**a))	(idem)
d.	Menuhin	[me.ˈnu.**~~h~~**ɪn]	[me.ˈnu.ʷɪn]	(me.(ˈnu.**~~h~~**ɪn))	(idem)
e.	Yamaha	[ja.ˈma.**~~h~~**a]	[ja.ˈma.a]	(ja.(ˈma.**~~h~~**a))	(idem)
f.	Asahi	[a.ˈsa.**~~h~~**i]	[a.ˈsa.i]	(a.(ˈsa.**~~h~~**i))	(idem)

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11 The form *marihuana* [ˌma.ri.ʲy.ˈʷa.na] (given by Gussenhoven 1993) is never realized with a medial [h] *(ˌma.ri).(**h**y.(ˈʷa.na)). Hence, we believe this is not a counterexample to the generalization in (40) but a case in which the postulation of an underlying /h/ is spurious, in spite of the orthography.

12 In a few words, /h/-deletion obligatorily applies in a foot-dependent syllable (Gussenhoven 1993):

a. Niehe [ˈni.ʲə] *[ˈni.hə] (ˈni.ʲə) (last name)

b. Neher [ˈne.ʲər] *[ˈne.hər] (ˈne.ʲər) (last name)

Even if underlying /h/ were postulated here (e.g., by Richness of the Base), the obligatoriness of /h/-deletion would follow from an absolute phonological gap in Dutch: /h/ is banned before schwa (Kager and Zonneveld 1986; Kager 1989; van Oostendorp 1995).

13 A few disyllabic words occur in which /h/ deletion seems to be blocked despite matching the metrical structure for deletion. These words all have identical vowels across /h/:

a. oehoe [ˈu.**h**u] ??[ˈu.ʷu] (ˈu.**h**u) ‘eagle-owl’

b. Soho [ˈso.**h**o] ??[ˈso.ʷo] (ˈso.**h**o) (idem)

(42) Onset of σ_2: /h/-deletion applies optionally

a.	coherent	[ˌko.**ħ**e.ˈrɛnt]	[ˌko.ʷə.ˈrɛnt]	(ˌko.**ħ**e).(ˈrɛnt)	(idem)
b.	Mohikaan	[ˌmo.**ħ**i.ˈkan]	[ˌmo.ʷi.ˈkan]	(ˌmo.**ħ**i).(ˈkan)	‘Mohican’
c.	prohibitie	[ˌpro.**ħ**i.ˈbi.tsi]	[ˌpro.ʷi.ˈbi.tsi]	(ˌpro.**ħ**i).(ˈbi.tsi)	‘prohibition’
d.	cohabiteer	[ˌko.**ħ**a.bi.ˈter]	[ˌko.ʷa.bi.ˈter]	(ˌko.**ħ**a).(bi.(ˈter))	‘cohabitate’
e.	nihilist	[ˌni.**ħ**i.ˈlɪst]	[ˌni.ʲɪ.ˈlɪst]	(ˌni.**ħ**i).(ˈlɪst)	(idem)
f.	jihadist	[ˌdʒi.**ħ**a.ˈdɪst]	[ˌdʒi.ʲa.ˈdɪst]	(ˌdʒi.**ħ**a).(ˈdɪst)	(idem)
i.	maharadja	[ˌma.**ħ**a.ˈrɑt.ja]	[ˌma.a.ˈrɑt.ja]	(ˌma.**ħ**a).(ˈrɑt.ja)	(idem)
j.	Tahamata	[ˌta.**ħ**a.ˈma.ta]	[ˌta.a.ˈma.ta]	(ˌta.**ħ**a).(ˈma.ta)	(last name)

Although the data in (40)–(42) require future instrumental verification, the optional deletion of /h/ in posttonic syllables by at least some speakers of Dutch and its retention in other unstressed syllables (39)–(40) can be tentatively taken as further evidence for the metrical representations proposed in this paper. Just as it occurred with vowel reduction, we distinguish between two types of unstressed syllables in Dutch /h/-licensing/deletion. On the one hand, unstressed syllables located in foot-initial position (i.e., σ_1 in (39), σ_3 in (40)), seem to block /h/-deletion. On the other hand, unstressed syllables in other (non-foot-initial) metrical positions (i.e., σ_2 in (41)–(42)) seem to optionally allow /h/-deletion. These generalizations together tentatively confirm the *foot-initial hypothesis* of Bennett (2012, 2013) by which foot-initial weak syllables can be slightly *stronger* than other unstressed syllables, given the greater relative strength associated to prosodic-category-initial positions. In Dutch, as in English, the feature [spread glottis] surfaces foot-initially as a means of strengthening a privileged position.[14]

14 In Dutch and English, the initial position of a minimal foot (a foot not dominated by a another foot, e.g., (ˈ**h**o.nɪŋ) ‘honey’) and the initial position of a maximal foot (a foot not dominated by another foot, e.g., (ˌɑl.mo).(**h**a.(ˈdɪst)) ‘Almohadist’) behave similarly: They both retain /h/ and, thus, they can be considered to be slightly stronger than other unstressed syllables. However, there are also languages like Huariapano (Bennett 2013), where only the initial position of maximal feet target strengthening effects. In this language, only the initial position of the maximal foot undergoes epenthesis of [h] in the coda, which leads to forms like (σh (σσ)) and (σh σ) with [h] epenthesis in the initial syllable but not *(σh (σh σ)) with insertion in the first and second syllable in the IL foot (Bennett 2013: 377). As a reviewer points out, neither the Dutch data nor the Huariapano data, permit us to test whether having two left foot brackets, e.g., **((**σ ˈσ) σ) is different from having only one left foot bracket **(**σ σ). Is the former a relatively stronger position than the latter? To test this, we would need to investigate an iambic language with traditional binary feet and IL ternary feet with a right adjunct and some kind of strengthening effect.

The alternating forms in (43) show that /h/-deletion is not subject to "identity" effects. That is, /h/ is optionally deleted in a non-foot-initial dependent position (43a.i)–(43f.i) even if there are morphologically related forms where /h/ is realized (43a.ii)–(43f.ii):

(43) /h/-zero alternations

a.	i.	Johan	(ˈjo.**ħ**ɑn)	(first name)
	ii.	Johannes	(jo.(ˈ**h**ɑ.nəs))	(first name)
b.	i.	Mohammed	(mo.(ˈ**h**ɑ.mɛt))	(idem)
	ii.	Mohammedaan	(ˌmo.**ħ**a).(mɛ.(ˈdan))	'Mohammedan'
c.	i.	nihil	(ni.(ˈ**h**il))	(idem)
	ii.	nihilist	(ˌni.**ħ**i).(ˈlɪst)	(idem)
d.	i.	jihad	(dʒi.(ˈ**h**at))	(idem)
	ii.	jihadist	(ˌdʒi.**ħ**a).(ˈdɪst)	(idem)
e.	i.	historisch	(ˌ**h**ɪs.(ˈto.ris))	'historical'
	ii.	prehistorisch	(ˌpre.**ħ**ɪs).(ˈto.ris)	'prehistorical'
f.	i.	habiliteer	(ˌ**h**a.bi).(li.(ˈter))	'habilitate'
	ii.	rehabiliteer	(ˌre.**ħ**a).(bi.li).(ˈter)	'rehabilitate'

In sum, it can be concluded that in Dutch, as in English, /h/ seems to be licensed in Ft-initial position, but it is optionally deleted elsewhere. This generalization captures the correct distributional patterns of /h/ summarized in (44).

(44) Correct predictions from the IL foot analysis:

a. Structural *dissimilarity* between the weak position σ_2 – *Ft-noninitial*; and the semi-weak position σ_3 – *Ft-initial*:
- a.i (ˌσ $\underline{\boldsymbol{\sigma_2}}$) (σ (ˈσ σ)) (ˌko.**ħ**a).(bi.(ˈter))
- a.ii (ˌσ σ) ($\underline{\boldsymbol{\sigma_3}}$ (ˈσ σ)) (ˌɑl.mo).(**h**a.(ˈdɪst))

b. Structural *similarity* between semi-weak positions σ_3 and σ_1 –*Ft-initial*:
- b.i (ˌσ σ) ($\underline{\boldsymbol{\sigma_3}}$ (ˈσ σ)) (ˌɑl.mo).(**h**a.(ˈdɪst))
- b.ii ($\underline{\boldsymbol{\sigma_1}}$ (ˈσ σ)) (**h**e.(ˈlas))

c. Structural *similarity* between the weak positions σ_2 – *Ft-noninitial*:
- c.i (ˌσ $\underline{\boldsymbol{\sigma_2}}$) (σ (ˈσ σ)) (ˌko.**ħ**a).(bi.(ˈter))
- c.ii (ˌσ $\underline{\boldsymbol{\sigma_2}}$) (ˈσ σ) (ˌko.**ħ**e).(ˈrɛnt)

To account for the structural dissimilarity between unstressed syllables in foot-initial domain versus non-foot-initial positions in OT, we propose an interaction of (positional) faithfulness and (general) markedness constraints: (i) the positional faithfulness constraint which preserves features in the foot-initial domain (INITIALFT-IDENT [F], see 32) and (ii) a markedness constraint against /h/ (*[spread glottis], Davis and

Cho 2003: 615). The former constraint specifically refers to the feature [spread glottis] (INITIALFT-IDENT[S.G]), and it dominates *[spread glottis]. This produces the Dutch /h/-deletion/licensing pattern: /h/ is licensed in weak syllables in foot-initial position (Tableau 45); /h/-deletion applies in weak posttonic syllables (Tableau 46).

(45)

/ɑlmohadɪst/	INITIALFT-IDENT[S.G]	*[spread glottis]	IDENT[S.G.]
☞ a. (ˌɑl.mo).(**h**a.(ˈdɪst))		*	
b. (ˌɑl.mo).(~~**h**~~a.(ˈdɪst))	*!		*

(46)

/koherɛnt/	INITIALFT-IDENT[S.G]	*[spread glottis]	IDENT[S.G.]
a. (ˌko.he).(ˈrɛnt)		*!	
☞ b. (ˌko.~~**h**~~e).(ˈrɛnt)			*

We now turn to the distribution of the glottal stop [ʔ], which displays a close parallelism with the distribution of [h].

5.4 Glottal stop insertion

In addition to vowel reduction and /h/-licensing/deletion, the distribution of the glottal stop in Dutch provides further tentative support for the metrical representations argued for in this paper. It has long been reported that [ʔ] is optionally inserted in the onset of initial syllables and stressed syllables (Jongenburger and van Heuven 1991). The data in (47)–(49) illustrate glottal insertion in the onset of initial syllables of different strengths: primary stressed (47), secondary stressed (48), and stressless (49). Note that [ʔ]-insertion in Dutch is always optional; in initial position, the preference for insertion is rather weak. Observe that these insertion contexts coincide with the left edge of a foot.

(47) Onset of initial primary stress: [ʔ]-insertion applies optionally (weak preference)

a.	aal	[ˈ**ʔ**al]	(ˈ**ʔ**al)	'eal'
b.	oost	[ˈ**ʔ**ost]	(ˈ**ʔ**ost)	'east'
c.	Iers	[ˈ**ʔ**irs]	(ˈ**ʔ**irs)	'Irish'
d.	ader	[ˈ**ʔ**a.dər]	(ˈ**ʔ**a.dər)	'vein'
e.	olie	[ˈ**ʔ**o.li]	(ˈ**ʔ**o.li)	'oil'

f. unie [ˈ**ʔ**y.ni] (ˈ**ʔ**y.ni) ‘union’
g. ananas [ˈ**ʔ**ɑ.nɑ.ˌnɑs] (ˈ**ʔ**ɑ.nɑ).(ˌnɑs) ‘pineapple’
h. alfabet [ˈ**ʔ**ɑl.fa.ˌbɛt] (ˈ**ʔ**ɑl.fa).(ˌbɛt) ‘alphabet’

(48) Onset of initial secondary stress: [ʔ]-insertion applies optionally (weak preference)
a. analoog [ˌ**ʔ**a.na.ˈloχ] (ˌ**ʔ**a.na).(ˈloχ) ‘analogous’
b. arabesk [ˌ**ʔ**a.ra.ˈbɛsk] (ˌ**ʔ**a.ra).(ˈbɛsk) ‘arabesque’

(49) Onset of initial stressless syllable: [ʔ]-insertion applies optionally (weak preference)
a. olijf [**ʔ**o.ˈlɛif] (**ʔ**o.(ˈlɛif)) ‘olive’
b. uniek [**ʔ**y.ˈnik] (**ʔ**y.(ˈnik)) ‘unique’
c. akela [**ʔ**ɑ.ˈke.la] (**ʔ**ɑ.(ˈke.la)) (idem)
d. Aïda [**ʔ**a.ˈʔi.da] (**ʔ**a.(ˈʔi.da)) (idem)
e. aorta [**ʔ**a.ˈʔɔr.ta] (**ʔ**a.(ˈʔɔr.ta)) (idem)
f. Elias [**ʔ**e.ˈli.ɑs] (**ʔ**e.(ˈli.ɑs)) ‘Elijah’
g. elite [**ʔ**e.ˈli.tə] (**ʔ**e.(ˈli.tə)) (idem)

Glottal insertion optionally applies in non-word-initial position, exclusively as a hiatus filling process in intervocalic contexts. Crucially, for [ʔ]-insertion to apply intervocalically, the preceding vowel must be low /a/; elsewhere, after non-low vowels, homorganic glide insertion occurs. Intervocalic [ʔ]-insertion is most likely to apply if the syllable is stressed. Examples illustrating this generalization are given in (50)–(51). Although insertion of [ʔ] is optional in these contexts too, there seems to be a greater preference for [ʔ]-insertion in the onset of non-initial primary stressed syllables (50). In the onset of non-initial secondary stressed syllables (52), [ʔ]-insertion applies optionally, at least in the first author’s speech and several speakers he consulted. The locus of insertion is again (as in (47)–(49)) the foot-initial position.

(50) Onset of non-initial primary stress: [ʔ]-insertion applies optionally (strong preference)
a. naïef [na.ˈ**ʔ**if] (na.(ˈ**ʔ**if)) ‘naive’
b. Aïda [ʔa.ˈ**ʔ**i.da] (ʔa.(ˈ**ʔ**i.da)) (idem)
c. aorta [ʔa.ˈ**ʔ**ɔr.ta] (ʔa.(ˈ**ʔ**ɔr.ta)) (idem)
d. Caïro [ka.ˈ**ʔ**i.ro] (ka.(ˈ**ʔ**i.ro)) (idem)
e. Haïti [ha.ˈ**ʔ**i.ti] (ha.(ˈ**ʔ**i.ti)) (idem)
f. chaotisch [χa.ˈ**ʔ**o.tis] (χa.(ˈ**ʔ**o.tis)) ‘chaotic’
g. Maori [ma.ˈ**ʔ**o.ri] (ma.(ˈ**ʔ**o.ri)) (idem)

h.	Laërtes	[la.ˈ**ʔ**ɛr.tɛs]	(la.(ˈ**ʔ**ɛr.tɛs))	(idem)
i.	paëlla	[pa.ˈ**ʔ**ɛl.ja]	(pa.(ˈ**ʔ**ɛl.ja))	(idem)
j.	Beëlzebub	[be.ˈ**ʔ**ɛl.zə.ˌbœp]	(be.(ˈ**ʔ**ɛl.zə)).(ˌbœp)	(idem)
k.	dadaïst	[ˌda.da.ˈ**ʔ**ɪst]	(ˌda.da).(ˈ**ʔ**ɪst)	(idem)
l.	cocaïne	[ˌko.ka.ˈ**ʔ**i.nə]	(ˌko.ka).(ˈ**ʔ**i.nə)	(idem)
m.	Israëlisch	[ˌʔɪs.ra.ˈ**ʔ**e.lis]	(ˌʔɪs.ra).(ˈ**ʔ**e.lis)	'Israel (adj.)'
n.	Caraïbisch	[ˌka.ra.ˈ**ʔ**i.bis]	(ˌka.ra).(ˈ**ʔ**i.bis)	'Caribbean'
o.	novocaïne	[ˌno.vo.ka.ˈ**ʔ**i.nə]	(ˌno.vo).(ka.(ˈ**ʔ**i.nə))	(idem)

(51) Onset of non-initial secondary stress: [ʔ]-insertion applies optionally (weak preference; at least, in the first author's speech and some speakers he consulted; other speakers match Booij 1995: [ˈfa.ra.o])

a.	farao	[ˈfa.ra.ˌ**ʔ**o]	(ˈfa.ra).(ˌ**ʔ**o)	'pharaoh'
b.	Israël	[ˈʔɪs.ra.ˌ**ʔ**ɛl]	(ˈʔɪs.ra).(ˌ**ʔ**ɛl)	(idem)
c.	Ismaël	[ˈʔɪs.ma.ˌ**ʔ**ɛl]	(ˈʔɪs.ma).(ˌ**ʔ**ɛl)	(idem)
d.	Rafaël	[ˈra.fa.ˌ**ʔ**ɛl]	(ˈra.fa).(ˌ**ʔ**ɛl)	'Raphael'
e.	Michaël	[ˈmi.χa.ˌ**ʔ**ɛl]	(ˈmi.χa).(ˌ**ʔ**ɛl)	(idem)
f.	Kanaän	[ˈka.na.ˌ**ʔ**ɑn]	(ˈka.na).(ˌ**ʔ**ɑn)	'Canaan'
g.	Sinaï	[ˈsi.na.ˌ**ʔ**i]	(ˈsi.na).(ˌ**ʔ**i)	(idem)
h.	Efraïm	[ˈe.fra.ˌ**ʔ**ɪm]	(ˈe.fra).(ˌ**ʔ**ɪm)	(idem)
i.	Nathanaël	[na.ˈta.na.ˌ**ʔ**ɛl]	(na.(ˈta.na)).(ˌ**ʔ**ɛl)	(idem)
j.	Nausicaä	[nɑu.ˈsi.ka.ˌ**ʔ**a]	(nɑu.(ˈsi.ka)).(ˌ**ʔ**a)	(idem)

Given its optional occurrence in foot-initial syllables, glottal stop insertion is predicted to optionally occur in the onset of unstressed foot-initial syllables word-medially. Forms that corroborate this prediction, at least in the speech of the first author and some speakers he consulted, are in (52).

(52) Onset of σ_3: [ʔ]-insertion applies optionally (weak preference; at least, in the first author's speech and some other speakers he consulted; this needs instrumental analysis)

a.	Israëliet	[ˌʔɪs.ra.**ʔ**e.ˈlit]	(ˌʔɪs.ra).(**ʔ**e.(ˈlit))	'Israelite' (n.)
b.	Kanaäniet	[ˌka.na.**ʔ**a.ˈnit]	(ˌka.na).(**ʔ**a.(ˈnit))	'Canaanite'
c.	Rafaëliet	[ˌra.fa.**ʔ**e.ˈlit]	(ˌra.fa).(**ʔ**e.(ˈlit))	'Raphaelite'
d.	cocaïnist	[ˌko.ka.**ʔ**i.ˈnɪst]	(ˌko.ka).(**ʔ**i.(ˈnɪst))	(idem)
e.	anaëroob	[ˌɑ.na.**ʔ**e.ˈrop]	(ˌɑ.na).(**ʔ**e.(ˈrop))	'anaerobe'
f.	paraënese	[ˌpa.ra.**ʔ**e.ˈne.sə]	(ˌpa.ra).(**ʔ**e.(ˈne.sə))	'paraenesis'

Contrary to these cases of optional insertion, the glottal stop has been claimed (Booij 1995) never to be inserted in post-stress, foot-medial onsets (see (53)–(54) below) and so, the process seems to be metrically conditioned: in foot-initial position there is a tendency to insert [ʔ], in foot-medial position glottal insertion fails to apply.

(53) Onset of final σ_2: [ʔ]-insertion *fails to* apply (Booij 1995)

a.	chaos	[ˈχa.ɔs]	(ˈχa.ɔs)	(cf. /ɑu/ *Gauss* [ˈχɑus] (same))
b.	Laos	[ˈla.ɔs]	(ˈla.ɔs)	(cf. /ɑu/ *laus* [ˈlɑus] ‘praise’)
c.	Tao	[ˈta.o]	(ˈta.o)	(cf. /ɑu/ *touw* [ˈtɑu] ‘rope’)
d.	Macao	[ma.ˈka.o]	(ma.(ˈka.o))	(cf. /ɑu/ *cacao* [ka.ˈkɑu] ‘cocoa’)
e.	Manao	[ma.ˈna.o]	(ma.(ˈna.o))	(cf. /ɑu/ *benauw* [bə.ˈnɑu] ‘stuffy’)
f.	Baäl	[ˈba.ɑl]	(ˈba.ɑl)	(cf. /a/ *baal* [ˈbal] ‘to be fed up’)
g.	Kaïn	[ˈka.ɪn]	(ˈka.ɪn)	(cf. /aj/ *design* [diˈzajn] (idem))
h.	Hawaï	[ha.ˈwa.i]	(ha.(ˈwa.i))	(cf. /aj/ *lawaai* [la.ˈwaj] ‘noise’)
i.	archaïsch	[ʔar.ˈχa.is]	(ʔar.(ˈχa.is))	(cf. /aj/ *mais* [ˈmajs] ‘maize’)

(54) Onset of nonfinal σ_2: [ʔ]-insertion fails to apply (Booij 1995)

a.	maoist	[ˌma.o.ˈɪst]	(ˌma.o).(ˈɪst)	(cf. /ɑu/ Maurits [ˈmɑu.rɪts] (name))
b.	taoist	[ˌta.o.ˈɪst]	(ˌta.o).(ˈɪst)	(cf. /ɑu/ causaal [kɑu.ˈsal] ‘causal’
c.	aoristus	[ˌʔa.o.ˈrɪs.təs]	(ˌʔa.o).(ˈrɪs.təs)	(cf. /ɑu/ laurier [lɑu.ˈrir] ‘laurel’)
d.	Aäron	[ˈʔa.a.ˌrɔn]	(ˈʔa.a).(ˌrɔn)	(cf. /a/ arend [ˈa.rənt] ‘eagle’)
e.	Faëton	[ˈfa.e.ˌtɔn]	(ˈfa.e).(ˌtɔn)	(cf. /aj/ Baikal [ˈbɑj.kɑl] (idem))
f.	aërobe	[ˌʔa.e.ˈro.bə]	(ˌʔa.e).(ˈro.bə)	(cf. /aj/ Nairobi [nɑj.ˈro.bi] (idem))
g.	aïoli	[ˌʔa.i.ˈo.li]	(ˌʔa.i).(ˈo.li)	(cf. /aj/ Jamaica [dʒa.ˈmɑj.ka] (id.))
h.	naïviteit	[ˌna.i.vi.ˈtɛit]	(ˌna.i).(vi.(ˈtɛit))	(cf. /aj/ Haifa [ˈhɑj.fa] (idem))

In a nutshell, the data presented in this section (47)–(54) provide additional tentative evidence for the need of incorporating IL feet in Dutch metrical structure. It also confirms the foot-initial hypothesis by which the left edge of a foot is a privileged position in prosody, which in this particular case is strengthened by means of inserting a glottal stop.

More interestingly, a close parallelism between the distribution of [h], vowel reduction and [ʔ] emerges in the speech of some speakers: [ʔ]-insertion also seems to apply less readily in the onset of a weak syllable in a posttonic position (σ_2) than in the onset of a weak syllable in a non-posttonic position (σ_3). Crucially, the latter is located in a foot-initial position and, hence, even if unstressed, it is more prominent than the former. The structural dissimilarity among unstressed syllables with respect to [ʔ]-insertion is illustrated in (55). In (55a) insertion fails to apply, in (55b) insertion applies optionally.

(55) Structural *dissimilarity* between weak position σ_2 – *Ft-NonInitial*; and semi-weak position σ_3 – *Ft-initial*:

a. Weak position σ_2: Ft-NonInitial

(ˌσ $\underline{\boldsymbol{\sigma_2}}$)	(ˈχa._ɔs)	'chaos'
(ˌσ $\underline{\boldsymbol{\sigma_2}}$) (σ (ˈσ σ))	(ˌna.**_i**).(vi.(ˈtɛit))	'naiveté'
(ˌσ $\underline{\boldsymbol{\sigma_2}}$)(ˈσ σ)	(ˌna.**_i**).(ˈvɪs.mə)	'naiveness'

b. Weak position σ_3: Ft-Initial

(ˌσ σ)($\underline{\boldsymbol{\sigma_3}}$ (ˈσ))	(ˌʔɪs.ra).(**ʔ**e.(ˈlit))	'Israelite (n.)'
(ˌσ $\underline{\boldsymbol{\sigma_2}}$) ($\underline{\boldsymbol{\sigma_3}}$ (ˈσ))	(ˌɑ.na).(**ʔ**e.(ˈrop))	'anaerobe'
(ˌσ $\underline{\boldsymbol{\sigma_2}}$)($\underline{\boldsymbol{\sigma_3}}$ (ˈσσ))	(ˌpa.ra).(**ʔ**e.(ˈne.sə))	'paraenesis'

Likewise, this metrical analysis, combined with the foot-initial hypothesis, captures both structural similarity between semi-weak positions σ_3 and σ_1, where [ʔ]-insertion applies optionally (in 56), and structural similarity between weak positions σ_2, where [ʔ]-insertion fails to apply (in 57):

(56) Structural *similarity* between semi-weak positions σ_3 and σ_1 –*Ft-initial*:

a.	(ˌσ σ) ($\underline{\boldsymbol{\sigma_3}}$ (ˈσ σ))	(ˌʔɪs.ra).(**ʔ**e.(ˈlit))	'Israelite (n.)'
b.	($\underline{\boldsymbol{\sigma_1}}$ (ˈσ σ))	(**ʔ**e.(ˈli.tə))	'elite'

(57) Structural *similarity* between the weak positions σ_2 – *Ft-noninitial*:

a.	(ˌσ $\underline{\boldsymbol{\sigma_2}}$) (σ (ˈσ σ))	(ˌna.**_i**).(vi.(ˈtɛit))	'naiveté'
b.	(ˌσ $\underline{\boldsymbol{\sigma_2}}$) (ˈσ σ)	(ˌna.**_i**).(ˈvɪs.mə)	'naiveness'

In Optimality-theoretical terms, a high-ranked constraint aligning particular features with the beginning of a foot can be said to be responsible for this positional licensing, which strengthens the acoustic and perceptual cues of a privileged position in prosody (Davis and Cho 2003). [ʔ]-insertion can be viewed as an augmentation of a strong position (Smith 2005). A possible interpretation in terms of laryngeal features that would subsume /h/-insertion would single out the natural class {ʔ, h} by the vocal chord settings [+stiff, -slack] (Halle and Stevens 1971), adopting a feature alignment constraint similar to the one proposed by Davis and Cho (2003). Alternatively, [ʔ]-insertion can be effected by an alignment constraint requiring a consonantal onset for the prosodic category foot: ALIGN-FTONSET ("Align the left edge of every foot with a consonant"; Goedemans 1996) dominating the faithfulness constraint against epenthesis (i.e., DEP-ʔ; Topintzi 2010). This interaction is illustrated in (58). In a form like [ˌɪsraeˈlit], the optimal candidate is one with glottal insertion in the first and third syllables (58a). The most faithful candidate (i.e., 58c) is ruled out, because [ʔ] is not aligned with the left edge of any of its feet. Likewise, the candidate that inserts a glottal stop only in word-initial position (58b) is factored out because [ʔ] has not been inserted at the left edge of the second foot.

(58)

/ɪsraelit/	Align-FtOnset	Dep-ʔ	Onset
☞ a. (ˌʔɪs.ra).(**ʔ**e.(ˈlit))		**	
b. (ˌ**ʔ**ɪs.ra).(e.(ˈlit))	*!	*	*
c. (ˌɪs.ra).(e.(ˈlit))	*!*		**

In the following tableau we see that foot-medially, [ʔ] is not inserted

(59)

/naivɪsmə/	Align-FtOnset	Dep-ʔ	Onset
a.(ˌna.**ʔi**).(ˈvɪs.mə)		*!	
☞ b. (ˌna.**i**).(ˈvɪs.mə)			*

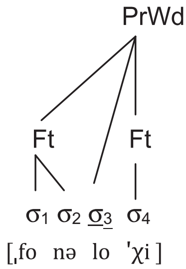
6 Alternative representational analyses

This section briefly examines five alternative metrical representations previously posited in the literature to account for the contrast between weak and semi-weak syllables in Dutch, pinpointing their respective shortcomings. It will be confirmed that even if some of these analyses can account for some of the phenomena described in this paper, the only representation that can provide a consistent account of all of them is an IL foot with a left adjunct.

The dual behavior of unstressed syllables has sometimes been explained in standard metrical theory by alluding to the difference between unstressed footed syllables *vs*. unstressed unfooted syllables directly linked to the prosodic word (Kager 1989; Gouskova 2003; Bye and de Lacy 2008; McCarthy 2008; Itô and Mester 2011). Since the weak branch of a foot has traditionally been characterized as the target of various reduction processes (e.g., vowel reduction, vowel syncope, deletion of segments, lenition), it has usually been considered to be weaker than unstressed syllables that are directly dominated by the prosodic word.[15] Adopting this approach to account for the Dutch facts, it could be argued that the third syllable in (60) is directly linked to the prosodic word, instead of a subsequent projection of the foot (Kager 1989).

15 Some studies have reported evidence from English children's early productions suggesting that unfooted weak syllables are more prone to omission than footed weak syllables (Gerken 1996; Pater 1997; McGregor and Johnson 1997). However, the authors have interpreted this phenomenon as supporting the binary trochee as the preferred target structure in children's output forms. Otherwise, very few studies have addressed the relative strengths of different kinds of weak syllables (footed vs. unfooted); future investigations would need to test this hypothesis against more data.

(60) Alternative analysis I: Stray adjunction to the Prosodic Word
PrWd

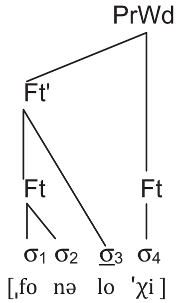


In fact, this representation is able to formalize the reported contrast between the second and third unstressed syllables in Dutch: whereas σ_2 is the dependent of a foot, σ_3 is an unfooted syllable (i.e., directly linked to the prosodic word). Since the two unstressed syllables have different structures, this representation correctly predicts that they might display different phonological behavior too. However, this representation suffers from two cardinal shortcomings. First, it fails to explain why *one* type of weak syllable (here, unfooted σ_3) is *stronger* than the other (footed σ_2), as evidenced by σ_3 resisting lenition processes such as vowel reduction and /h/-deletion, and being targeted by strengthening processes such as glottal insertion. That is, this metrical structure fails to rationalize the observed strength difference between unfooted σ_3 and foot dependent σ_2 and hence, this strength difference must be stipulated. Second, this representation fails to account for the similarity between initial syllables and word-medial semi-weak σ_3: why should it be that σ_3 is targeted by strengthening (licensing /h/ and [ʔ]) similarly to stressed syllables (in particular, σ_1) although these syllables are located in different metrical positions? As we argued in Section 5, none of these shortcomings arise in a framework with IL feet with a left adjunct.

A second alternative representation that was posited in several traditional studies of Dutch to account for some of the facts discussed in this article is an IL foot with a right (rather than left) adjunct – a dactyl (Booij 1982; Gussenhoven 1993).[16] For the sake of comparison, this representation is schematized in (61):

16 Such a structure had been previously proposed for English too, e.g., Selkirk (1980), McCarthy (1982).

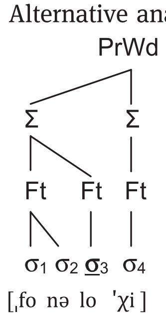
(61) Alternative analysis II: IL foot with a right adjunct



Although this representation is quite similar to the one proposed in this article, it lacks explanatory power. First, it cannot explain why the third syllable is slightly stronger than the second syllable, since both syllables are dependents in foot-final position. Second, it is unable to predict the close parallelism between word-initial syllables ($σ_1$) and word-medial unstressed syllables in a pretonic non-posttonic position ($σ_3$). Remember these positions are characterized as semi-weak because they (i) undergo strengthening effects such as /h/-licensing and [ʔ]-insertion and (ii) resist vowel reduction to a greater extent than other unstressed syllables. Both observations are straightforwardly accounted for in a framework with IL feet with left (rather than right) adjuncts.

A third alternative analysis was proposed by van Oostendorp (1995),[17] and recently reintroduced by Nazarov (2009), to account for vowel reduction patterns in Dutch. This structure, which incorporates the *superfoot* as a new category in the prosodic hierarchy is presented in (62):

(62) Alternative analysis: the superfoot

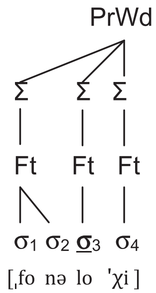


17 Elaborating earlier proposals by van der Hulst and Moortgat (1981).

In this representation, the prosodic word dominates two superfeet (Σ); the first superfoot dominates two feet: binary (σ_1 σ_2) and unary (σ_3), and the second superfoot dominates the final foot. To capture the difference between weak syllables (σ_2) and semi-weak syllables (σ_3), this approach provides a different structure to each of these syllables: σ_3 is slightly stronger than weak σ_2 because it is the head of a stressless foot, whereas σ_2 is in a foot-dependent position. Despite the descriptive adequacy of this approach in capturing the strength difference between weak and semi-weak syllables, there are several reasons for favoring an analysis with IL feet over a superfoot account. First, the analysis in (62) needs to posit a new category in the prosodic hierarchy: the superfoot. In contrast, our analysis is based on independently established categories in the prosodic hierarchy and thus makes fewer assumptions about universal constituents (see Itô and Mester 2007 *et seq*. for the superiority of a single-category approach as opposed to a model that introduces new categories in the hierarchy). Note that an IL foot is just an additional projection of the foot: the same foot targeting processes apply to the two projections (e.g., vowel reduction, /h/-licensing/deletion, glottal insertion). In contrast, the incorporation of the superfoot implies that different processes would target this category. Nevertheless, there is not clear independent evidence for this category. In the structure above, the motivation for projecting a superfoot in the last syllable in the word remains unclear. Also, it is unclear why the third syllable (which is stressless) projects a degenerate foot, apart from this being necessary to account for its greater resistance to vowel reduction: this gives up the assumption that each metrical foot constitutes a stress domain (Davis and Cho 2003). Finally, a potential problem for the prosodic structure in (62) is that it might predict more than two degrees of stress in Dutch, which have not been attested. The syllable constituting the final foot could be said to be the strongest: it is the head of the prosodic word and it carries primary stress. The first syllable, making up the head of the first foot and the head of the first superfoot, carries secondary stress. But then, the third syllable, which is in a foot head position too, could be expected to carry tertiary stress. Even if there are cases of stressless feet in the literature and we do not deny their existence, we consider it to be suspicious that the only foot that does not carry stress in Dutch is precisely the one that needs to be posited *ad hoc* to account for the prominence difference among unstressed syllables.

A final alternative representation is a variant of the superfoot structure which is briefly discussed by Davis and Cho (2003) (who give credit to Harry van der Hulst) is shown in (63): σ_3 is parsed as a degenerate foot, which surfaces as stressless. But unlike (62), the degenerate foot is immediately dominated by the prosodic word, instead of a superfoot.

(63) Alternative analysis: Degenerate foot

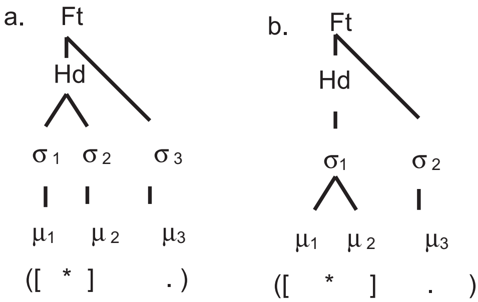


Here, just as in the superfoot analysis, $σ_3$ is stronger than $σ_2$ by virtue of the fact that it is in its own foot, not being a foot-dependent. The virtue of (63) over the superfoot analysis is that it needs to posit no new category in the prosodic hierarchy. However, otherwise, it runs into similar objections: introducing the degenerate foot gives up the assumption that each metrical foot constitutes a stress domain. The notion that the foot corresponds one-to-one to stress is well-founded; it is arguably the most consistent assumption about feet that has survived since the concept of foot emerged in the late 1970's. Hence we believe that the burden of evidence for the notion "degenerate foot" rests on its proponents. Note that Hayes (1995: 109) judged the need for additional descriptive power that is provided by stressless feet to be "doubtful".

Before proceeding to the conclusions of this article we would like to clarify that the IL foot is not a mere revival of Dresher and Lahiri's (1991) or Rice's (1992) layered foot, known as the "resolved" foot. There is a small but important difference between the two types of feet which is crucial when trying to account for the Dutch facts exposed here. As illustrated in (64), the resolved foot consists of an obligatory binary flat head plus an optional dependent, whereas the head of the IL foot is always unary.[18]

18 Since the above-mentioned authors used two representations to mark prominence (metrical structure and gridmarks) we include both in the representations. (The square brackets delimit the complex head, while parentheses denote foot boundaries.)

(64) Layered feet with a binary symmetric head (Dresher and Lahiri 1991; Rice 1992)



In our model, the binary innermost constituent in an IL foot is never flat qua prominence, but it has an asymmetric status: it is actually a foot by itself (a trochee in Dutch) and hence, the *true* head of the ternary foot corresponds exclusively to a single constituent at the next-lower level down the prosodic hierarchy. Although highly similar, the two models make different predictions with respect to the relative prominence of their constituents. Within the resolved foot model in (64), the elements in the binary head have identical status and, hence, it is expected that they display similar prominence properties and similar phonological activity. This prediction, however, is not borne out in Dutch, where one of the constituents in the trochee undergoes weakening effects (vowel reduction and /h/-deletion) whereas the other constituent is stressed. Hence, one of the most significant differences between the two representations is that the resolved foot falls short of predicting which of the two syllables/morae in the head receives stress. Since the elements in the head are mapped onto a single gridmark, both might surface as stressed. Furthermore, note that even if a gridmark was uniquely associated to one element in the head, this representation would still be problematic in a different respect: it predicts that the two elements in the head pattern identically in metrically conditioned phenomena like vowel reduction or /h/-deletion. But this is clearly not the case in Dutch. To sum up, the symmetric flat head in (64a)–(64b) makes it impossible to account for cases in which the vowel of only one syllable in the binary head is reduced. In contrast, if the *binary head* has *foot status* per se (i.e., one of its syllables/morae is the true head of the foot, the other one a dependent) as proposed for Dutch, vowel reduction and other weakening processes can be correctly predicted to occur only in the weak branch of the foot. Even though the resolved foot may capture prominence differences between elements in the head, this is achieved in a less economical way than in a IL foot. In particular, to capture prominence differences among elements within the head, the resolved foot model must rely on disjoint representations of prominence: gridmarks and metrical constituency (cf. Rice 1992: 139). In contrast, the recursive foot model offers a unified representation of prominence.

7 Conclusions

In this article we have presented several arguments based on stress and non-stress evidence that back up the analytical benefits of introducing IL feet with a left adjunct in Dutch metrical representations. These arguments add to the theoretical arguments for IL feet based on cross-linguistic foot-dependent processes and metrical typology in recent studies (Martínez-Paricio 2013; Martínez-Paricio and Kager 2015). Moreover, by identifying a set of phonological processes in Dutch that refer to foot-initial positions, on a par with similar processes and foot representations in English (Withgott 1982; Jensen 2000; Davis and Cho 2003), we have provided additional evidence in support of Bennett's (2012, 2013) foot-initial hypothesis, according to which weak syllables in a foot-initial position are eager to undergo strengthening effects and resist lenition processes, in contrast to weak syllables in other metrical (non-foot-initial) positions. Overall, we have demonstrated that such an approach provides the underlying motivation for the otherwise puzzling dual behavior of unstressed syllables in Dutch. Our theoretical contribution resides not so much in setting up the notion of IL foot, which dates back to Selkirk (1980) and Prince (1980), nor do we claim credit for having found empirical evidence for IL feet from foot-based processes in Germanic languages, which was done by Jensen (2000) and Davis and Cho (2003). Our contribution resides in fitting the Dutch/English IL foot into a wider typological landscape, based on principles and constraints that were independently motivated in the typology of metrical stress systems and metrically conditioned strengthening/weakening processes (Martínez-Paricio 2013; Martínez-Paricio and Kager 2015). Our analysis has another virtue, viz. of unifying Dutch vowel reduction with (partly new data for) /h/-deletion and glottal insertion.

The current paper re-emphasizes the dual role of the prosodic category "foot" as the domain of metrical stress and a domain of metrically-dependent phonological process. Foot structure is crucial to connect metrical stress and metrically dependent processes, suggesting that alternative models which deny the relevance of foot structure and which view stress as a property of syllables, are overly simplified. Phonological processes that refer to stressed syllables and a specific type of unstressed syllables, to the exclusion of other types of unstressed syllables, can only be stated in a unifying and explanatory way by referring to structural positions in prosodic domains between the "syllable" and "word". We have taken this classical argument for the category "foot" (e.g., Dresher and Lahiri 1991; Hayes 1995) one step further by providing evidence for the foot as a minimally recursive layered category; metrically dependent phonological processes simultaneously refer to "foot-initial position" as the strong syllable in head position in the minimal foot, as well as the weak syllable in an initial dependent. This unification of contexts of application by means of layered foot structure emphasizes that IL feet are necessary not only to account for ternary stress patterns (Martínez-Paricio and Kager 2015) but also constitute an adequate representation to account for additional prominence contrasts, such as contrasts between "weak" and "semi-weak" syllables. Our current results also underscore the importance of independent evidence (non-stress) to support metrical stress analyses.

Future experimental work on Dutch prosody will aim at further supporting our hypothesis about the role of IL feet as the domains of metrically dependent processes. More specifically, the data presented here should be confirmed by an experimental study (acoustical analysis and/or well-formedness judgments). Given there is a certain degree of variation between native speakers in the realization of some of the processes studied here, a future study should also attempt to describe and model this variation. In this respect, it would be interesting to investigate if speakers differ by constraint rankings or in terms of metrical representations.

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