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WEIGHT, FINAL LENGTHENING AND STRESS:
A PHONETIC AND PHONOLOGICAL CASE STUDY OF
NORWEGIAN

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Abstract

Weight, final lengthening and stress:
A phonetic and phonological case study of Norwegian

by

S.L. Anya Lunden

Many languages, including Norwegian, exhibit CVC weight asymmetry: CVC is usually heavy but behaves as light word-finally. It is proposed that this asymmetry is motivated by facts of phonetic length and human perception. A theory of weight is advanced in which a syllable shape in a given position is only heavy if it, on average, is sufficiently proportionally longer than an unstressed (necessarily light) CV in the same position. A syllable will need to be extra-long word-finally in order to be categorized as heavy because a final CV is notably longer than a non-final CV due to final lengthening. Analyzing weight as requiring a minimum proportional increase reflects human perception of differences: the same raw increase has less of a perceptual effect when added to a relatively long stimulus. Using the results of a production study it is shown that heavy syllables in Norwegian are at least 60% greater than unstressed CV syllables in the same position, putting the weight criterion at a 60% proportional increase. It is shown that a final CVC falls short of this proportional increase threshold with only an average increase of 27% over a same-position CV.

The stress system of Norwegian is analyzed in detail, taking the categorization of syllable weight to be pre-determined by the weight criterion. Evidence for the stress pattern of the language is drawn from the lexicon and the results of a novel
word experiment administered to native Norwegian speakers. The regular stress patterns in the language are shown to include not only the predominant stress pattern of the language but also several minor patterns, predictable exceptions to the basic pattern. This identification of basic and minor patterns in conjunction with the weight criterion based on the proportional increase threshold allows for a more motivated and complete analysis of Norwegian stress than has previously been proposed.

The proportional increase theory of weight provides a phonetically and perceptually motivated explanation for the CVC weight asymmetry thus replacing final consonant extrametricality, the traditional descriptive mechanism. Other forms of extrametricality are proposed to be reinterpretable if the perceptual consequences of final lengthening are considered. While the analysis of weight is consistent with the basic tenets of moraic theory, a departure is made from standard moraic theory which takes moras to be prosodic units associated directly to segments. The theory of weight proposed treats moras a property of syllables as a whole.
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Chapter 1

Introduction

1.1 CVC weight asymmetry

Syllables of the shape CVC present a weight asymmetry in many languages, including Arabic (McCarthy 1979), English (Chomsky & Halle 1968), Estonian (Prince 1980), Greek (Steriade 1980), a dialect of Hindi (Hayes 1981, citing Mohanan 1979), Icelandic (Kiparsky 1984), Menomini (Hayes 1995), Norwegian (Kristoffersen 1991), Ponapean (McCarthy & Prince 1986), Romanian (Steriade 1984), Swedish (Riad 1992), and Swiss German (Spaelti 1994). These languages are among those that treat coda consonants as heavy. In standard moraic theory (Hyman 1985, McCarthy & Prince 1986, Hayes 1989), these languages employ Weight-by-Position, the requirement that a consonant in coda position is associated with a mora.
As shown in (1), CVC syllables are heavy (bimoraic), as expected, in non-final positions. But we find that these languages treat CVC syllables in word-final position as light (monomoraic). The traditional explanation for this is that word-final consonants are extrametrical; that is, word-final consonants are exempt from the lower levels of metrical structure.

As shown in (2), final consonants are taken to be exempt from lower prosodic structure in languages which normally apply Weight-by-Position but treat a word-final CVC as though it were light. I propose a reanalysis of how weight is determined that makes final consonant extrametricality unnecessary.

I suggest that word-final CVC syllables count as light because syllables in word-final position are subject to final lengthening, causing the duration of a final CVC to be not as perceptually distinct from a final CV as a non-final CVC is from a non-final CV.
Final lengthening is a cross-linguistic phenomenon that occurs at the right edge of prosodic boundaries. Thus we find increased length at the right edge of the word, the phrase, and the utterance (Oller 1973, et al.).

The increased duration at the right edge of the word means that a final CV syllable is significantly longer than a non-final CV syllable. It is a known fact of perception that if a shorter and a longer duration are increased by the same amount the increase to the shorter duration will be perceptually greater. This aspect of human perception is credited to Ernst Heinrich Weber (1795–1878) who performed experiments with the perception of weight and, later, of sight and hearing.\(^1\) He found that the smallest noticeable difference was essentially proportional to the starting unit. For example, the difference between a 100 gram weight and a 110 gram weight was paralleled at a higher level by a 1000 gram weight and a 1100 gram weight. The decibel scale encodes this same perceptual discrepancy for loudness: each raw increase on the decibel scale is greater than the one before it but all increases are perceptually equivalent.

Standard moraic theory encodes a segment’s weight (or lack of weight), not its length. However, there is a connection between syllable weight and syllable length. Heavy syllables are (unsurprisingly) longer than light syllables (Broselow, Chen, & Huffman 1997).\(^2\) I show, using data from Norwegian speakers, that heavy

\(^1\)I am indebted to a participant of the LSA annual 2006 conference who drew my attention to Weber’s work.

\(^2\)Duanmu (1994) demonstrated this for Mandarin and Shanghai, although weight in these languages is only relevant for tone assignment. Zhang (2002) argues that tone association is not dependent on the mora count of a syllable and so while Duanmu demonstrates what seems to be a durational correlate of weight, his findings are open to reanalysis. Hubbard (1995) shows that vowel quantity is the most important factor in determining medial vowel duration in Bantu languages (specifically Luganda and Runyambo). Gordon (2002) shows that a language may group syllable shapes into weight categories based on duration, where shapes with longer durations count as heavy.
syllables are significantly longer than light syllables. I assume that in order to be perceived as heavy, a syllable must be sufficiently longer than a light syllable in the same position. In non-final position, a coda consonant causes a length increase that sufficiently differentiates the duration of a closed syllable from that of a CV syllable. In final position, however, the increase in duration due to a coda consonant is not sufficient to differentiate a CVC from a CV syllable to the same degree. This is shown schematically in (3).

(3) The same increase does not have the same perceptual effect (Weber’s law)

a. i. \[ \text{ } + x \]
   
   ii. \[ \text{ } \]

b. i. \[ \text{ } + x \]
   
   ii. \[ \text{ } \]

The first and second bars in the pairs in (a) and (b) in (3) are separated by the same raw increase in length (x). However, the two bars in (a) are more perceptually distinct than the two in (b). This is true both looking at the lengths visually and if they were audible. The perceived distinction between the two bars in (a) and (b) is different from the actual distinction between them because humans are more sensitive to increases to smaller amounts (Weber’s law). Thus, the increase x to the relatively short bar in (a-i) seems greater than the increase x to the relatively long bar in (b-i). If we want to achieve the same perceived increase to the bar in (b-i) we need a greater raw increase.
A greater raw increase is needed for the same perceivable difference

a. i. \[\text{[bar]} + x\]
   ii. \[\text{[bar]}\] 60% increase

b. i. \[\text{[bar]} + x\]
   ii. \[\text{[bar]}\] 30% increase

c. i. \[\text{[bar]}\]
   ii. \[\text{[bar]}\] 60% increase

The first bar in (c) is as long as the first bar in (b). The third pair of bars are separated by more than x but the perceptual difference between them is the same as the perceptual distance between the two bars in (a). Although a greater raw increase is needed in (c) to equal the perceptual distance in (a), the proportional increase remains constant.

Gordon (2002) has shown that light and heavy syllables in a language group according to duration and energy. While he found that a syllable’s energy was a better correlate of weight categorization than its duration was, I assume Norwegian is a language where duration is primary, due to the prevalence of non-sonorant codas, including voiceless stops, in heavy syllables. Syllables closed with such consonants are presumably heavy because of their durational distinction from light syllables, rather than because of an important increase in energy. Starting from the position that heavy syllables are perceptually longer than light syllables I assume that the duration contrast between light and heavy syllables is perceptually important and, further, that the contrast is maintained in all positions within a
word. I propose that in order for a syllable shape in a given position to be categorized as heavy it must be consistently realized as sufficiently longer than an unstressed CV syllable in the same position. The increase necessary to be sufficiently longer is an empirical question, taken to be related to the level at which the duration of a syllable is clearly perceptually distinct from a CV syllable in the same position. It follows that additional length is needed for word-final syllables to be categorized as heavy. The same raw increase (adding a coda consonant) does not sufficiently distinguish a CVC syllable from a CV syllable in word-final position because of the additional length due to final lengthening. Therefore the same raw difference in duration does not correctly model syllable weight distinctions, since the raw increase needed non-finally will be insufficient in final position. The proportional increase of a heavy syllable over a CV syllable in the same position, however, is consistent across positions. This is illustrated in (5) where these claims about syllable shape and position are matched up with the contrasts previously illustrated.
(5) Perceptual basis of CVC weight asymmetry

non-final
a. i. CV + x
i. CVC

final
b. i. CV + x
ii. CVC

c. i. CV
ii. CVXC

I assume that a non-final CVC is heavy because the extra duration due to the final consonant perceptually distinguishes the duration of a CVC from that of non-final CV. I propose that a final CVC is light because a final CV is so long due to final lengthening that the added duration due to a coda is not sufficient to set the two syllables apart perceptually. This difference relies on the fact of human perception that increases in duration are less noticeable when added to already long durations. In order to achieve the same perceptual difference between light and heavy syllables present in non-final positions, a heavy syllable in word-final position must be extra-long, that is, have three segments in the rime. The contrast in duration between such a final CVXC syllable and a final CV is claimed to be perceptually the same as is found between a non-final CV and CVC.

This proposal differs radically from the solution offered by final consonant extrametricality. Rather than discounting the final consonant, the length provided by the final consonant in a CVXC syllable is crucially needed in order to set the
duration of a heavy syllable in final position apart from a final CV syllable. Final consonant extrametricality is one instance of final constituent extrametricality. Extrametricality is a theoretical device, proposed to capture the cases where word-final constituents do not play a role in the metrical structure of a word (see, for example, Hayes 1982). While my proposal specifically reanalyzes final consonant extrametricality, I suspect that other types of extrametricality are amendable to a more motivated analysis as well. I address this question further in chapter six.

In the remainder of this chapter I review the three areas which serve as the underpinnings of my proposal: moraic theory, including the historical development of extrametricality and how it is treated in optimality theory (OT) (Prince & Smolensky 1993), prosodic final lengthening, and basic facts about the stress system of Norwegian, a language with CVC weight asymmetry. The theory of weight introduced here will be motivated by phonetic data from Norwegian, introduced in chapter two and shown in chapter three to fit the general schema shown in (5). A detailed analysis of Norwegian stress is given in chapters four and five. Chapter six looks beyond Norwegian to other types of languages traditionally analyzed with extrametricality.

1.2 Moraic theory and extrametricality

In this section I review the main points of the standard contemporary analysis of syllable weight. The weight of a syllable is taken to be the sum of the moras it dominates, where a mora is a prosodic unit. Word-finally, the weight of a given syllable shape may be diminished by the parsing of a final segment outside the syllable. This idea is recast in optimality theory as a condition that stress not be
word-final (NonFinality). The section concludes with problems faced by this view of final syllable weight.

1.2.1 Moraic theory

Classical (pre-generative) moraic theory distinguishes between light (monomoraic) and heavy (bimoraic) syllables. All languages in which weight plays a role in the phonology count CV syllables as light and CV: syllables as heavy. As noted in §1.1, languages vary as to whether they treat CVC syllables as light or heavy. I classify closed syllables as heavy in my discussions of weight, as all languages that exhibit CVC weight asymmetry (necessarily) treat (non-final) closed syllables as heavy. Medial geminates are represented here and elsewhere with the notation “CVC:”, where a syllable boundary is shown before the length mark (as the second half of the geminate occurs in the following syllable). Long vowels are notationally distinguished from diphthongs, where CVV specifically refers to diphthongs.

(6) Light and heavy syllable shapes

<table>
<thead>
<tr>
<th>Light (µ)</th>
<th>Heavy (µµ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV</td>
<td>CV:, CVV</td>
</tr>
<tr>
<td></td>
<td>CVC CVC:</td>
</tr>
</tbody>
</table>

Prosodic processes, such as stress assignment, are sensitive only to a syllable’s weight, not to its segmental content. This means that heavy syllables, regardless of their segmental content, are equivalent. The categorization of syllables by weight harks back to Latin and Greek metrics.

Standard moraic theory (Hyman 1985, McCarthy & Prince 1986, Hayes 1989) goes further by taking moras to be associated with particular segments. This cap-
tures the fact that onsets do not contribute to the weight of a syllable (e.g. a CCV syllable is a light syllable). Under standard moraic theory a segment contributes to the weight of a syllable if and only if it is associated with a mora. This also captures the fact that mora-bearing segments can be shown to have longer duration than non-mora-bearing segments. The work of Hubbard (1994), Broselow, Chen & Huffman (1997), and Ham (2001), for example, has demonstrated that segments that contribute to syllable weight are durationally distinct from featurally identical segments that do not contribute to weight. Hayes (1989) showed that compensatory lengthening (CL) facts fall out if we assume that weight-contributing segments are associated to moras. If a consonant that contributes to syllable weight is deleted, languages will lengthen the vowel, thus preserving the weight of the syllable. We do not find compensatory lengthening when a consonant that does not contribute to syllable weight deletes.

(7)

<table>
<thead>
<tr>
<th>Association</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>σ</td>
<td>shorter duration</td>
</tr>
<tr>
<td>/</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>will not cause CL if deleted</td>
</tr>
<tr>
<td>/</td>
<td></td>
</tr>
<tr>
<td>σ</td>
<td>longer duration</td>
</tr>
<tr>
<td>/</td>
<td></td>
</tr>
<tr>
<td>μ</td>
<td></td>
</tr>
<tr>
<td>/</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>will cause CL if deleted</td>
</tr>
</tbody>
</table>

Under standard moraic theory, a syllable’s weight is the sum of the moras it dominates. Therefore, in a language that assigns a mora to coda consonants, we expect a CVC syllable to be heavy. The fact that CVC syllables pattern as light word-finally in many languages is therefore unexpected. It was proposed that
another force was in play word-finally, one which discounted a final constituent before prosodic structure was assigned. In the following section I give an overview of extrametricality, with specific attention to final consonant extrametricality.

1.2.2 Extrametricality and NonFinality

The idea that the last syllable did not count for stress was first proposed by Liberman and Prince (1977), who were looking at English words ending in a suffix that ended in y [i], such as -ory and -ary. In Chomsky and Halle (1968) this final y was represented underlingly as the non syllabic glide /j/ in order to capture the fact that final [i] doesn’t play a metrical role (as a glide is non-syllabic). Liberman & Prince use the term “extrametrical” (p 293) for such syllables. They note that other words seem to behave similarly and by marking the final syllable of such words as extrametrical the same stress rule as the language uses elsewhere can still apply. So at the cost of some extra rules, like the one adjoining stray syllables after stress has been assigned, their system is able to account for the seemingly exceptional stress of many words.

Hayes (1979) expanded on this proposal of morphological extrametricality by showing that a language could consistently discount the final syllable for the purposes of stress assignment. One language Hayes analyzes as having regular, final syllable extrametricality is Classical Arabic. The basic observation in Classical Arabic is that the rightmost heavy syllable is stressed, but word-finally, heavy syllables are treated as light and superheavy syllables are treated as heavy (superheavy syllables only occur word finally). This can be summarized as in (8).
Stress assignment in Classical Arabic (McCarthy 1979)

1. Stress the final syllable if it is superheavy

2. Otherwise stress the rightmost non-final heavy syllable

3. Otherwise stress the initial syllable

McCarthy (1979) proposes that superheavy syllables have, in fact, two distinct rimes underlyingly, the first being a branching rime of the shape VV or VC and the second being the final C. While superheavy syllables are pronounced as single syllables, this analysis reflects the fact that in Classical Arabic superheavy syllables arise from a rule that deletes a word-final short vowel at a phonological phrase boundary. (Presumably this is historically how superheavy syllables arose in modern Arabic languages). McCarthy assumes such consonants are the rime of a degenerate syllable, defining "rime" as the right branch of a syllable. As such consonants are adjoined to the last syllable, they constitute the right branch (the only branch) of that syllable. Other work (e.g. Steriade 1982, Rice 1999) refers to parallel consonants as onsets of degenerate syllables. As a further syllable is involved under either analysis, I will refer such analyses as proposing a final degenerate syllable, as shown in (9).

(9) Final degenerate "syllable"

```
PrWd
... σ  σ^{degen}
  C V C#
```
Hayes’ analysis of Classical Arabic (building on McCarthy 1979) discounts the final syllable for stress. In words with final consonants this means that a final degenerate syllable (consisting of only a consonant) will be discounted. The formation of a degenerate final syllable consisting of the final consonant will have the effect of making a final CVC syllable light and therefore unavailable for stress. A final superheavy syllable will be merely heavy once the final consonant is parsed as a separate, degenerate syllable, but as the rightmost heavy syllable it will receive stress.

(10) Syllabic parsing of a final CVXC syllable

This proposal allows a simplification of the stress facts in Classical Arabic, especially in light of the fact that extrametricality seems to be employed by a number of languages (Hayes 1982). The revised stress algorithm is given in (11) (ignoring footing facts).

(11) Stress assignment in Classical Arabic with extrametricality (Hayes 1979)

1. Mark the final syllable as extrametrical (where the final C in CVC, CVVC and CVCC is a final, degenerate syllable)

2. Stress the rightmost heavy syllable

3. Otherwise stress the initial syllable
Once the final consonant (couched as a syllable) has been discounted, the stress assignment algorithm does not have to consider final syllables separately from non-final syllables, and so the stress assignment portion of the algorithm in (11) is simpler than the algorithm stated in (8).

Final segment extrametricality was independently proposed by Mohanan in 1979 for a dialect of Hindi (in an oral presentation, summarized in Hayes 1980) and by Steriade (1980) for Ancient Greek. In Ancient Greek final syllables with long vowels, a final consonant cluster, triphongs and diphthongs followed by a consonant are all counted as heavy. In contrast, other rime shapes which would word-internally cause a syllable to be considered heavy are treated as light word-finally: a final consonant and diphthongs. It therefore seems that the final segment, whether a consonant or a heterorganic vowel, is marked as extrametrical.

Hayes (1981) revisits his analysis of Arabic in light of the facts in Hindi, as described by Mohanan in his 1979 talk. While the stress algorithm for Hindi is the same as that of Classical Arabic, superheavy syllables are not restricted to word-final position. McCarthy proposed his analysis of final consonants in superheavy syllables because such syllables arose from final short vowel deletion. However, this is not the case in Hindi and so Mohanan proposed the final segment, rather than the final syllable, be marked as extrametrical in Hindi. This works because final superheavy syllables will become heavy (and therefore stressable) when the final C is marked as extrametrical. Final heavy syllables (CVV or CVC) will have their final segment (V or C) marked as extrametrical and therefore the syllable will become light (CV) and unstressable. A final light syllable will lose its rime and presumably become a degenerate syllable. Hayes (1981) points out that final
segment extrametricality is also a possible analysis of Classical Arabic, producing the same pattern.

Hayes (1982) proposes limitations for extrametricality. He proposes that a single constituent (such as segment, syllable, foot) may be set aside (treated as extrametrical) at word boundaries. This has the benefit of uniting what would otherwise be language particular caveats to an analysis under a theoretical umbrella. While there are a few cases of proposed initial extrametricality, we find the need to assume constituents are set-aside overwhelmingly at the right edge of a word.

In the framework of optimality theory (OT), where the grammar is viewed as a set of ranked constraints (Prince & Smolensky 1993), extrametricality has been recast as a prohibition against final stress, encoded through the constraint NONFINALITY. Its definition, as originally formulated by Prince and Smolensky (1993: 52), is given in (12).

(12) NONFINALITY: No head of PrWd is final in PrWd

This definition does not allow the syllable bearing the main stress or the head foot to be word-final. While NONFINALITY has the same effect as the traditional notion of extrametricality, it is formulated differently. Instead of removing a final constituent from the metrical structure of the word, it poses a well-formedness condition on the placement of stress. In this approach there is assumed to be a reason or reasons why final stress is marked.

Prince and Smolensky note casting the phenomenon in terms of NONFINALITY rather than as extrametricality predicts that there will be languages which usually obey NONFINALITY but are forced to violate it under certain circumstances. This
is in fact the case, since monosyllabic words are stressed on the final (only) syllable. While this final stress in monosyllabic words is a strange exception when framed in terms of extrametricality it arises naturally in OT.

Although the approach changed, NONFINALITY captures the same phenomenon that extrametricality did. A simple analysis of a Latin word is given in (14) to illustrate, looking only at NONFINALITY and RIGHTMOST. Feet are binary over moras.

(13) RIGHTMOST-BY-σ: No syllable intervenes between the main stress and the right edge of the prosodic word (McCarthy 2003)

(14) Example of extrametricality in OT (Latin amiːkus ‘friend’)

<table>
<thead>
<tr>
<th></th>
<th>/amiːkus/</th>
<th>NONFINALITY</th>
<th>RIGHTMOST-BY-σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. a(miː)kus</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. amiː(kús)</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

The two constraints involved, NONFINALITY and RIGHTMOST-BY-σ, are in conflict with each other. While NONFINALITY prohibits stress on the final syllable, RIGHTMOST-BY-σ requires that the main stress be at the right edge. It is assumed that languages like Latin, traditionally analyzed with final syllable extrametricality, rank NONFINALITY above RIGHTMOST-BY-σ. This has the effect of placing the main stress as rightward as possible (given foot structure constraints) without landing on the final syllable.

Final consonant extrametricality is also captured by NONFINALITY, as a language may violate strict prosodic succession and have a final consonant directly dominated by the prosodic word.
By associating the final consonant directly with the prosodic word, stress on either of the two syllables will not violate NonFinality as neither the stressed syllable nor the head foot will be word-final, due to the final consonant that is set off from the lower prosodic structure. However, the final consonant in (15) is an appendix (Rubach & Booij 1990, Rosenthal & van der Hulst 1999) and therefore violates strict prosodic succession (Selkirk 1984, Nespor & Vogel (1986), Ito & Mester 2003/1992, Hyde 2003). The prosodic hierarchy is given in (16).

(16) Prosodic hierarchy (Selkirk 1984)

\[
\begin{align*}
\phi & \quad \text{phonological phrase} \\
Wd & \quad \text{prosodic word} \\
Ft & \quad \text{foot} \\
\sigma & \quad \text{syllable} \\
\mu & \quad \text{mora}
\end{align*}
\]

As the prosodic parsing of the final consonant in the templatic word in (15) skips intermediate prosodic levels it violates *Append-to-PrWd (Rosenthal & van der Hulst 1999), the constraint prohibiting attachment of a segment directly to the prosodic word.
An example of how a pattern previously analyzed with final consonant extrametricality would be captured with NONFINALITY is given in (17), using an English verb as the example. The prosodic structure is indicated rather than shown hierarchically. Periods in the output candidates represent syllable boundaries and the parentheses represent feet. Note that the final consonant is parsed outside the rightmost syllable and foot in the winning candidate. Feet are taken to be binary over moras.

(17) 'construct'

<table>
<thead>
<tr>
<th>/kanstrakt/</th>
<th>NONFINALITY</th>
<th>RIGHTMOST by-σ</th>
<th>APPEND-TO SYLLABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. kən.(strákt).t</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. kən.(strákt)</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. (kán).strakt</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

Although stress is on the final syllable in the winning candidate, NONFINALITY is obeyed because the final consonant is excluded from lower prosodic structure. By excluding the final consonant from lower prosodic structure, stress is able to fall on a more rightward syllable than would be possible if APPEND-TO-SYLLABLE were obeyed.

Weaknesses of the extrametricality and NONFINALITY approaches to the problem of CVC weight asymmetry are discussed in the following section.

1.2.3 Outstanding issues

It is not clear what motivates extrametricality/NONFINALITY, apart from the fact that something special needs to be said about the right edge of the word for the
analysis of stress in many languages. A possible explanation for NonFinality is that it avoids stress clash (discussed in Gordon 2000, Karvonen 2004). Stress clash would occur if NonFinality were violated and the initial syllable of the following word were stressed. While this is a possible explanation for final syllable extrametricality, it still potentially puts two stressed syllables next to each other in languages with final consonant extrametricality. This situation is shown in (18).

(18) Clash even when NonFinality is obeyed

\[ CV.CV.C \text{PrWd} \quad [C\text{V:C}]\text{PrWd} \]

Since final superheavy syllables are pronounced as monosyllabic, despite their representation, clash will still occur. In fact, even final syllable extrametricality will only cause stress clashes to be avoided if adjacent words are both greater than two syllables. Given that shorter words are generally common, clash avoidance is a suspect motivation for extrametricality/NonFinality.

Gordon (2000) notes further problems with extrametricality that extend to NonFinality. He points out that it cannot account for languages like Chickasaw and Klamath which allow CVVC to be stressed word finally but not CVCC, despite the fact that syllables closed with a consonant are treated as heavy in non-final position. This is a finer distinction than final consonant extrametricality or NonFinality is able to make. Further, he notes that if the goal is avoidance of clash, we should see more languages with peninitial stress, parallel to the large number of languages found with penultimate stress.

\[ ^{3}\text{I want to thank Jaye Padgett for drawing this to my attention.} \]
The OT analysis of final consonant extrametricality is troubling because it links the property of allowing an appendix with whether a final consonant is discounted for stress. These things should be independently variable. We must presume that all languages traditionally analyzed with final consonant extrametricality in fact allow a final appendix. This is suspicious if the only evidence for an appendix is whether the language appears to metrically discount the final consonant.

There are alternatives to the structure illustrated in (15) that do not rely on a final appendix. Final consonants have also been analyzed as part of a further, final syllable. Kiparsky (1991), Kager (1995), and Burzio (1994) have taken them to be part of a catalectic syllable (a word-final null vowel). Harris (1994) argues they are the onset of a final, degenerate syllable (in the spirit of McCarthy’s (1979) original analysis of word-final consonants in Arabic). Rice (2006) takes word-final consonants in Norwegian to be part of a further, final syllable although this is not independently motivated for the language. McCarthy, in his 1979 proposal of a final degenerate syllable, says that CVVC and CVCC syllables are “clearly single syllables by any measure of surface syllabification” (p 10). This is certainly true in Norwegian. Unrealized syllables are theoretical devices to explain stress patterns more generally, as extrametricality is. If the stipulation can regularize an otherwise complicated pattern, then it is motivated, but only by necessity. It would be preferable to capture the facts with a clearly motivated, non-postulatory explanation.
1.3 Final lengthening

The fact that segment duration varies at prosodic boundaries has been noted at least since Oller (1973), for English and Lindblom and Rapp (1973) for Swedish. Phonetic final segment lengthening is found at the right edge of words, phrases and utterances. It has been demonstrated that final lengthening affects the rime of the syllable preceding the prosodic boundary (Crystal & House 1990, Wrightman et al. 1992), where the final segment is lengthened more than other segments in the final rime. While I am not aware of previous phonetic work investigating final lengthening in Norwegian, it has been demonstrated that Swedish (a closely related language) has final lengthening at the word, prosodic word, prosodic phrase, and prosodic utterance levels (Lindblom & Rapp 1973, Horne et al. 1995).

Final lengthening occurs in music (Lindblom 1978), as well as in speech, showing it to be a wide-ranging phenomenon. I am not aware of any language that has been shown not to have final lengthening. I do not give a review of the proposals for the reason behind final lengthening, but do note that speakers are sensitive to different degrees of final lengthening. Studies, such as Klatt (1976), Nooteboom & Doodeman (1980), and Wrightman et al. (1992), have linked amounts of final lengthening to speakers’ perception of prosodic boundaries. There is evidence that final lengthening helps in syntactically parsing an utterance (see, for example, Lehiste et al. 1976, Cooper & Paccia 1977, Streeter 1978, Cooper 1978). Final lengthening has also been found to be emphasized in infant-directed speech.

4Nickerson et al. 1974 found an absence of final lengthening in the speech of the deaf. However, phrase final lengthening occurs in American Sign Language (Liddell 1978, Wilbur 1999).
in Swedish (Koponen & Lacerda 2003), giving additional evidence that it assists listeners in assigning structure.

1.3.1 Influence of final lengthening on syllable weight

I suggest there is a connection between the fact that final lengthening occurs in the rime of the final syllable of the word and the CVC weight asymmetry. Some syllable shapes and their associated weights are shown for Norwegian in (19).

(19) Syllable shape, position, and weight in Norwegian

<table>
<thead>
<tr>
<th></th>
<th>non-finally</th>
<th>word-finally</th>
</tr>
</thead>
<tbody>
<tr>
<td>light</td>
<td>CV</td>
<td>CV, CVC</td>
</tr>
<tr>
<td>heavy</td>
<td>CV:, CVC</td>
<td>CV:C, CVCC</td>
</tr>
</tbody>
</table>

Here we have two phenomena that relate to word-final position: final lengthening and the fact that a word-final rime must be greater than VC to be categorized as heavy. Both contribute to word-final syllables being phonetically longer than non-final syllables, as they are always phonetically lengthened and they can have three rime segments (if stressed). The proposal introduced in §1.1 proposes a connection: additional phonological material is needed in final position in order for the rime to be categorized as heavy, a distinction which requires a sufficient proportional increase over an unstressed CV syllable in the same position.

A connection between word-final lengthening and stress placement has previously been made by Ahn (2000). Ahn reasons for stress placement preferences based on the contrasts present in a sequence of syllables. For example, she proposes that stressing a final CV or CVC when it is adjacent to a penultimate CV: (in a language with phonemic vowel length) makes for a bad phonemic length contrast.
This is because the phonetic lengthening due to stress on top of the additional length in final position would cause the phonologically short vowel in a final CV or CVC to be almost as long as the phonologically long vowel in penultimate position. The penult is therefore stressed over the final syllable in such a situation. Instead of comparing syllables in different positions to each other I am suggesting that weight is categorized as a result of the comparison of a syllable to a CV syllable in the same position. Thus a syllable’s weight does not depend on the shape of other syllables in the word. Stress assignment is then taken to proceed as normally analyzed, with no inter-syllable comparison.

1.4 Overview of Norwegian

Norway has two nationally recognized languages. One is Bokmål ("book language"), historically an Eastern Scandinavian language derived from Danish, since Danish was the language of the government while the country was under Danish rule (lasting about 400 years, until 1814). The dialects actually spoken in Norway, however, are historically Western Scandinavian and therefore more closely related to Icelandic and Faroese than to the Mainland Scandinavian languages, Danish and Swedish. These dialects vary considerably and, for a long time, had no written standard (as Bokmål was used for writing). In order to give the Norwegian dialects national representation, Ivar Aasen combined aspects of different dialects into a single language, Nynorsk ("new Norwegian") in the mid 1800s. This gave Norway a second national language which was more closely related to the Norwegian actually spoken. Therefore, no one speaks Bokmål or Nynorsk natively. Norwegians speak the dialect (having more in common with Nynorsk
than Bokmål) of their area and learn both national languages in school. Each community chooses one or the other as the main written language in the area.

The phonetic studies reported on in chapters two and four were carried out in Lyngdal, a town in Southern Norway. I will refer to the language of this region by the name of the county, the Vest-Agder dialect. The dialect of the area belongs historically with the Western Scandinavian languages, as all the regional dialects do. The language of written communication in the area is Bokmål, however. I am not aware of any differences in stress between the dialects, Nynorsk, and Bokmål. Therefore, while there are phonemic, phonetic, and tonal differences between these languages, to my knowledge the stress system is the same. Almost all variants of Norwegian have a requirement that a stressed syllable must be heavy, including Bokmål, as it has been influenced by Norwegian dialects. (Danish does not have this requirement and so allows light syllables to be stressed without augmentation.) Therefore, while I will make clear the regional bias of my experiments, I expect the results and the claims made based on these results to hold up for other dialects of Norwegian and to be true of Norwegian generally.

1.4.1 Phonemic inventory of Norwegian

Norwegian has long vowels and geminates but they occur only in stressed syllables. This means that vowel length is not contrastive, since CV and CV: never occur under the same stress conditions, rather it is the difference between CV:.C and VC.: that speakers distinguish ([háː.kə] (‘chin’) vs. [há.kə] (‘pick’), but *[há.kə]). Stressed syllables must be heavy, and in stressed syllables speakers distinguish
vowel length from consonant length. A stressed syllable may also be CVC with a singleton vowel and coda (and a heterorganic following onset).

I follow Kristoffersen (2000) in representing the mid long and short vowels as having a different quality. While all short vowels differ some in quality from their long counterparts it is most pronounced in the mid vowels (particularly in the front unrounded vowel).

(20) Vowels of Norwegian

<table>
<thead>
<tr>
<th>/i:/i</th>
<th>/y:/y</th>
<th>/u:,u</th>
<th>/ø:,ø</th>
<th>/œ,œ</th>
</tr>
</thead>
<tbody>
<tr>
<td>æ,æ</td>
<td>ø,ø</td>
<td>œ,œ</td>
<td>æ,æ</td>
<td>æ,æ</td>
</tr>
</tbody>
</table>

Not all dialects have [æ] (in its long and short versions) but it is present in the Vest-Agder dialect of southern Norway. Orthographically the vowels are represented transparently, except [ɯ] is written ‘u’, [u] is written ‘o’ and [o] is written ‘å’.

The consonants of the Vest-Agder dialect are given in (21).

(21) Consonants of Vest-Agder Norwegian

<table>
<thead>
<tr>
<th>stop</th>
<th>fricative</th>
<th>nasal</th>
<th>liquid</th>
<th>glide</th>
</tr>
</thead>
<tbody>
<tr>
<td>p,b</td>
<td>f,v</td>
<td>m</td>
<td>l</td>
<td>j</td>
</tr>
<tr>
<td>t,d</td>
<td>s,ç</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k,g</td>
<td>r</td>
<td>η</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

25
Norwegian is known for its retroflex consonants, which have received attention in the literature. However, they are not part of the Vest-Agder dialect and so I have excluded them from the consonant chart above. The quality of the rhotic varies dialectally. In the Vest-Agder area it is a voiced uvular fricative. Other areas have a flap/tap, trill and/or retroflex r.

1.4.2 Quantity and length in Norwegian

As mentioned, Norwegian (like Swedish, but unlike Danish) requires that stressed syllables be heavy. Final stressed syllables, apart from open diphthongs, require three segments in the rime. An inventory of syllable types is shown in (22). The grayed syllable shapes are heavy. (It is important to note that CVV represents only a diphthong, not a long vowel.)

(22)

<table>
<thead>
<tr>
<th></th>
<th>unstressed</th>
<th>stressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>non finally</td>
<td>CV, CVV, CVC</td>
<td>CVV, CVC, CV, CVC:</td>
</tr>
<tr>
<td>finally</td>
<td>CV, CVV, CVC</td>
<td>CVV, CV: C, CVC:, CVCC</td>
</tr>
</tbody>
</table>

The fact that vowel and consonant length is dependent on stress is a result of the fact that the historical quantity contrast has been lost. Old Norse could contrast each independently, as shown in (23).
Further, stressed syllables were not necessarily heavy. Examples of Old Swedish are given in (24) and exemplify the possible syllable shapes in Old Norwegian as well.

(24) Old Swedish (from Riad 1992)

a. [gá.ta] ‘street’

b. [brý:.ta] ‘to break’

c. [bín.da] ‘to bind’

d. [fál.la] ‘to fall’

e. [gá:r.þer] ‘yard’

f. [dó:t.ter] ‘daughter’

The loss of independently distinctive vowel and consonant length is referred to as the quantity shift. As Riad (1992) describes it, many Scandinavian dialects went from “a quantity system where segmental quantity determine[d] the weight of the stressed syllable, to a quantity system where prosody determines the weight of the stressed syllable” (p 235). Before the quantity shift vowel and consonant length were phonemic. The result of the quantity shift was that a weight requirement was imposed on all syllables: stressed syllables needed to be heavy while unstressed syllables needed to be light. Loan words have since given rise to unstressed heavy
syllables (for example, the initial syllables in *al.ma.nákk* (‘almanac’) and *sjas.mún* (‘jasmine’)). However, syllables in loan words that would surface as stressed and light are augmented so that they surface as heavy.

Although there is no longer a phonemic length contrast in the language, lexicon optimization (Prince & Smolensky 1993) predicts that both long vowels and geminates will be present in underlying representations, as the surface form of a word is stored. However, we may assume that a syllable that would otherwise surface as light and stressed is subject to a default form of augmentation (either vowel or consonant lengthening).

As long vowels and geminates are both able to occur in stressed syllables, there are surface minimal pairs such as those in (25). Long vowels are not represented orthographically, but the contrast is framed in terms of vowel length when taught in Norwegian schools. Norwegian students are taught that in the absence of a syllable-final consonant the vowel is long when stressed. Geminate consonants are represented orthographically as a double consonant.

(25) a. non-final heavy stressed syllables

(i)  [hâːkə] *hake*  ‘chin’
    [hakkə] *hakke*  ‘pick’

(ii) [hɛːtə] *hete*  ‘heat’
    [hetta] *hette*  ‘hood’
b. final superheavy stressed syllables

<table>
<thead>
<tr>
<th>(i)</th>
<th>[steːg] steg</th>
<th>‘step’</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[stegg] stegg</td>
<td>‘male quail’</td>
</tr>
<tr>
<td>(ii)</td>
<td>[hatt] hat</td>
<td>‘hatred’</td>
</tr>
<tr>
<td></td>
<td>[hatt] hatt</td>
<td>‘hat’</td>
</tr>
</tbody>
</table>

Non-finally, if an underlyingly light syllable receives stress it will be augmented to be heavy. Although length is dependent on stress we cannot assume that both long vowels and geminates are only surface phenomena since this would result in non-distinct underlying forms for surface minimal pairs. Kristoffersen (2000) proposes that neither long vowels or geminates are underlying but assumes that each word is lexically marked for vowel or consonant lengthening. An alternative that does not require lexical specification would be to assume that one or the other was present underlyingly and the other derived under stress.

Both vowel length and consonant length have independently been argued to be underlying (see Elert 1964, Witting 1977, et al. for underlying vowel length; Eliasson 1978, Riad 1992, Rice 2006, et al. for underlying consonant length). Many researchers have pointed out that the crucial point is that either kind of length is a realization of quantity; that length is prosodic, not segmental (Fretheim (1969/1983), Eliasson (1978, et al.), Haugen (1967), Kristoffersen (1991, 2000), et al.).

Speakers are conscious of vowel length but not particularly aware of consonant length, suggesting that vowel length is underlyingly contrastive and gemination occurs only when an otherwise light syllable would surface stressed. However, this

---

5The works cited in this paragraph conflate proposals for Norwegian with those concerned with Swedish, as the representation of length is an issue for both languages.
analysis has the cost of doubling the phonemic vowel inventory of the language, which is suspicious, given that vowel length is only contrastive in stressed syllables. Eliasson (1978) proposed that phonetically long consonants (in Swedish) can be analyzed as two identical consonants. Following this view, I assume that geminates, when present, are present underlyingly. Therefore syllables that would otherwise surface as light and stressed are augmented through vowel lengthening. Independent support for underlying consonantal length is discussed in §3.2.1.

### 1.4.3 Native and loan words

True native Norwegian nouns are maximally disyllabic. Further, disyllabic words have only one possible stress placement since they all end in schwa. This means that the native vocabulary fits multiple possible analyses. Stress could be said to be always initial or it could be analyzed as always on the rightmost (potentially) heavy syllable. Stress could even be said to be consistently penultimate, with an obvious exception when the word is monosyllabic. We may distinguish between these analyses by considering loan words, which are a substantial part of the vocabulary. Loan words are not limited to one or two syllables and come in a variety of shapes. Under the assumption that the native and loan words of Norwegian are united under a single stress system, the analysis chosen for the native words will be dependent on the behavior of the loan words.

Since native words have only one syllable which can be plausibly stressed they are consistent with the initial stress of Proto-Germanic. These native words are assumed to have been reanalyzed at some point to fit with an emerging stress system which included loan words. It is reasonable as well as desirable to unite
the analyses of stress in native and loan words as both are sizable components of
the core vocabulary of modern Norwegian.

1.4.4 Stress pattern of Norwegian

I give examples of words that I take to be examples of usual stress assignment
in Norwegian and then describe this pattern. In the tables below, CVC: syllables
are included in the notation CVCC (word finally) and CVC (non-finally). (The
spelling is given, with the addition of vowel length, when present.)

(26) Examples of underlying shapes that result in final stress

<table>
<thead>
<tr>
<th>/...CVCC/#</th>
<th>gloss</th>
<th>/...CVC/#</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>elefánt</td>
<td>‘elephant’</td>
<td>tulipá:n</td>
<td>‘tulip’</td>
</tr>
<tr>
<td>horisónt</td>
<td>‘horizon’</td>
<td>basá:r</td>
<td>‘raffle’</td>
</tr>
<tr>
<td>alárm</td>
<td>‘alarm’</td>
<td>basú:n</td>
<td>‘basoon’</td>
</tr>
<tr>
<td>almanákk</td>
<td>‘almanac’</td>
<td>sjaká:l</td>
<td>‘jackal’</td>
</tr>
<tr>
<td>klarinétt</td>
<td>‘clarinet’</td>
<td>tomá:t</td>
<td>‘tomato’</td>
</tr>
<tr>
<td>bagatéll</td>
<td>‘trifle’</td>
<td>dipló:m</td>
<td>‘diploma’</td>
</tr>
</tbody>
</table>
Examples of underlying shapes that result in non-final stress

<table>
<thead>
<tr>
<th>/...CVC.CV/ gloss</th>
<th>/...CV.CV/ gloss</th>
<th>/CVC.CV.CV/ gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>mánigo ‘mango’</td>
<td>lárna ‘llama’</td>
<td>índigo ‘indigo’</td>
</tr>
<tr>
<td>distánse ‘distance’</td>
<td>dráma ‘drama’</td>
<td>dóngeri ‘denim’</td>
</tr>
<tr>
<td>disíppel ‘disciple’</td>
<td>égo ‘ego’</td>
<td>émbryo ‘embryo’</td>
</tr>
<tr>
<td>brudúlje ‘ruckus’</td>
<td>gamásje6 ‘spats’</td>
<td>brókkoli ‘brokkoli’</td>
</tr>
<tr>
<td>fiásko ‘fiasko’</td>
<td>epócke ‘era’</td>
<td>kénguru ‘kangaroo’</td>
</tr>
</tbody>
</table>

I claim that stress falls on the final syllable when possible. The final syllable may bear stress if it is underlyingly /CVC/ or /CVCC/. (In the former instance it will be augmented to CV:C.) Stress is otherwise penultimate, a light /CV/ being augmented to CV:. The quantity sensitive nature of the language can be seen in words that have the shape /CVC.CV.CV/. In such cases the antepenult, rather than the penult, will be stressed, as it is underlyingly heavy. Thus, we may state the basic stress pattern as in (28).

(28)    a. If the word ends in a consonant, stress the final syllable
       b. Otherwise, stress the penult
       c. Unless the penult is light and the antepenult is heavy, in which case, stress the antepenult

There are exceptions to this pattern, some of them predictable. For example, [s]-final words are very likely to have penultimate rather than final stress. We find antepenultimate stress in words with final hiatus (/CV.CV.V/) rather than the penultimate stress predicted by (28). Then there are words such as bíson

6The penultimate syllable in this word is not closed: the spelling ‘sj’ represents the voiceless palatal fricative.
(‘bison’) which seem to just be singular exceptions to the basic pattern. Regular stress patterns, both the basic pattern predicted by (28) and the minor patterns such as those just mentioned, are analyzed in optimality theory in chapters four and five, along with a discussion of true exceptions. Evidence is brought not only from the lexicon of Norwegian but also from the results of a novel word experiment.

1.5 Conclusion

The fact that word-final consonants do not contribute weight in many languages that otherwise treat CVC as heavy has previously been mysterious. The usual method for dealing with the CVC weight asymmetry stipulates that the final consonant is set off from lower prosodic structure. While a useful theoretical device, it has no phonetic grounding, as final consonants are pronounced as part of the final syllable. I argue that the CVC weight asymmetry is due to an intersection of three factors: heavy syllables are those that are clearly perceived as longer than light syllables, final syllables are markedly longer than non-final syllables because of final-lengthening at the word level, and human perception of length contrasts is sensitive to consistent proportional increase rather than consistent raw increase. I show, using the results of a production experiment, that Norwegian is consistent with an analysis that categorizes syllable weight based on a syllable’s proportional increase over an unstressed CV (light) syllable in the same position. The CVC weight asymmetry can then be explained straightforwardly and without special reference to the final syllable.
A production experiment that used controlled words to gain relative measurements of light and heavy syllables is reported on in chapter two. The proposed weight criterion is presented in detail in chapter three, where results of the Norwegian duration study are shown to fit the general schema presented above in (5). The consequences for moraic theory are then discussed. Chapter four gives a detailed analysis of the basic stress pattern of Norwegian in OT, based on the results of the second experiment, in which speakers’ placement of stress on novel words was recorded. Chapter five continues the analysis of Norwegian stress, dealing with exceptions to the basic pattern, some of which are proposed to be regular and are classified as minor stress patterns. The proposed minor patterns reduces the number of exceptions to the basic pattern, which reduces the number of words that must be assumed to have something special about them underlyingly. The analysis of Norwegian stress proposed is therefore motivated (by the results of the two experiments) and simpler than previous proposals. Finally, further possibilities for the reanalysis of extrametricality are discussed in chapter six.
Chapter 2

A phonetic study of length in Norwegian

2.1 Introduction

This chapter reports on production experiments undertaken to investigate the factors that contribute to a syllable’s duration, with an eye to the correlation between syllable duration and syllable weight. In §2.2 the assumption that duration plays a primary role in the perception of stress in Norwegian is supported and the main correlates of duration are discussed. The methods and results of a pilot study investigating syllable duration are presented in §2.3. Given the results from the pilot experiment, a follow-up experiment with more syllable shapes was performed. The methods and results of this experiment are presented in §2.4. The main focus throughout is on the effect of stress and position on syllable duration. It is shown in §2.4.3 that the experiment results are an example of a model of the duration contrast argued in §1.1 to be necessary for a weight distinction.
2.2 Variables pertaining to stress

Stress is a difficult property to investigate because it does not have one clear phonetic correlate. Stressed syllables involve greater physical effort by the speaker than non-stressed syllables do (see, for example, Lehiste 1970). Greater physical effort of the muscles involved in respiration increases the subglottal pressure (the amount of air pressure produced by the lungs). This causes faster vocal fold vibration which results in a higher fundamental frequency (F0), perceived as higher pitch. Further, greater subglottal pressure is in turn responsible for greater sound pressure, resulting in higher intensity of the sound waves, perceived as increased loudness. A stressed syllable usually has greater duration as well. The perceptual correlates of stress, then, are (higher) pitch, (increased) loudness and (increased) duration. These are all qualities that must be evaluated by the listener with respect to unstressed syllables in the same utterance.

Fry (1955, 1958) performed experiments to determine the cues American English speakers rely on to identify a stressed syllable. In his earlier study (1955), he found that while both duration and intensity played a role, duration was the stronger cue. This was somewhat surprising, as previously it had been thought that speakers relied on loudness as the key perceptual marker of stress. His later (1958) study took fundamental frequency (pitch) into account, as well as duration and intensity. His earlier finding was repeated, that duration plays a larger role in the perception of stress than intensity. In addition, he found that listeners were also sensitive to an increase in pitch, although, unlike duration and intensity, a pitch increase had an all-or-nothing effect on the perception of stress. That is, it was the fact that there was a pitch increase, not the amount of the increase, that
mattered to the listeners. Further, when increased duration was compared with increased pitch it was found that listeners relied more heavily on the increase in pitch as a cue to stress.

### 2.2.1 Dependent variable: duration

The two main cues for stress, then, seem to be duration and pitch. However, Norwegian has a pitch accent; a lexical high prominence tone that contrasts with its absence. In words without the lexical pitch accent, the pitch peak corresponds with the stressed syllable. In words with lexical pitch accent, however, the pitch peak is delayed and occurs to the right of the stressed syllable (Lorentz 1995).

(1) Pitch peak shifts to the right of the stressed syllable in words with lexical pitch accent (Lorentz’ (8): 43)

<table>
<thead>
<tr>
<th>a. H* L_B</th>
<th>No lexical pitch accent</th>
</tr>
</thead>
<tbody>
<tr>
<td>låkenø</td>
<td>‘the bed sheet’</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b. L H* L_B</th>
<th>lexical pitch accent</th>
</tr>
</thead>
<tbody>
<tr>
<td>kåkenø</td>
<td>‘the cakes’</td>
</tr>
</tbody>
</table>

The fact that the position of the pitch peak carries phonemic information (there are minimal pairs distinguished only by the presence or absence of the lexical pitch accent) means that it is not always a reliable cue for stress.

Duration, however, is a very good cue for stress in Norwegian because, in addition to phonetic lengthening under stress, as found in English, stressed syllables must be heavy. Heavy syllables are longer than light syllables because of the additional phonological material. As discussed in §1.4.2, syllable weight and stress correlate very closely in Norwegian. Long vowels and geminate consonants only
occur under stress. Therefore both phonological and phonetic length are strong cues to stress in the language.

In the following experiment, I consider only duration as the phonetic correlate of stress. While pitch and intensity may also be stress cues, it seems clear that duration is a particularly strong one in Norwegian. Using pitch is problematic for the reason discussed above; the lexical pitch accent forces the pitch peak off the stressed syllable. Stressed syllables doubtlessly have greater intensity than unstressed syllables but measurements of syllable intensity will not correlate directly with stress because of the relatively large number of voiceless and stop codas, including geminates, in the language. Therefore an unstressed CVn may have a greater intensity than a stressed (final) CVtt. What seems more relevant, and directly related to stress, is duration.¹

2.2.2 Independent variables: stress, position

As discussed in the preceding section, stressed syllables are longer than unstressed syllables. In Norwegian, this is due both to the fact that stressed syllable are heavy (while most unstressed syllables are light), and therefore longer due to increased phonological content, and to phonetic lengthening under stress. In most cases it is not possible to separate the two because a given syllable shape only occurs under stress. The table in (22) in chapter one is repeated here to show the different shapes that occur under different stress levels in non-final and final positions. (Diphthongs are omitted as they are heavy in all positions and were not considered in the production experiments.) The grayed syllable shapes are heavy.

¹Thanks to Matt Gordon for discussion of this point.
Because syllable weight correlates strongly with primary stress only one of these two factors, stress, is considered in the following experiment. Thus the effects of phonological length under stress and phonetic lengthening under stress are combined.

Another potential factor that is highly correlated with stress is the number of segments in the rime. This cannot be modeled as an independent variable because it so heavily overlaps with stress level, and to some degree, with syllable position. All syllables with one rime segment are unstressed, all with three rime segments are stressed and in final position. Those with two segments in the rime may be either stressed or unstressed in non-final positions, but only unstressed in final position. Including rime size in the model therefore would not offer an accurate picture of its effect.

The second factor that affects syllable duration is position. As discussed in §1.3, phonetic final lengthening occurs at the right edge of the word. Specifically, the final rime is phonetically longer than non-final rimes with the same content. Therefore the position of the syllable in the word must be taken into consideration in a model of rime duration.
2.3 Pilot experiment

A pilot study was undertaken to begin investigation into the effect of stress and position on duration and to determine what factors and factor levels were relevant. While syllable weight is determined by the segments in the rime, not the onset, of a syllable, onset length could still possibly vary under stress. One goal was to determine whether the duration of the entire syllable should be modeled, or only the duration of the rime. Another question is whether, assuming alternating stress, we find increased duration under secondary stress, or only under primary stress. While only primary stressed syllables have a weight requirement, phonetic investigation of Dutch, for example, has revealed lengthening under both primary and secondary stress (Rietveld, Kerkhoff & Gussenhoven 2004). The experiment is first described and these questions are then addressed along with other experiment results.

2.3.1 Methods

The data consisted of nonsense words of three syllables. The nonsense words had the voiceless stops [p, t, k] in the three onset positions and the vowel [a] in all of the nucleus positions. Only one vowel quality was used in order to control for known variances in the inherent length of different vowels (Lindblom 1968). The voiceless stops were chosen since they are maximally distinct from vowels and therefore most easily distinguished in a spectrogram. The stimuli contained all possible permutations of the stops, as shown in (3).
Each of these six permutations were marked for every possible main stress, using the typographical notation of capital letters (KAtapa, kaTApa, kataPA, etc.), resulting in 18 (6 x 3) stimuli that will have a long vowel in the stressed syllable (as stressed syllables must be heavy). Each of the words in (3) was also included in the data set with one medial consonant geminated (KATtapa, kaTAPpa, etc.), resulting in 12 additional tokens (6 x 2). Finally, each of the words in (3) were given a final geminate [tt] (kataPATT, kapaTATT, etc.), adding six more tokens. Thus 36 words were included in the data set, half involving vowel length under stress, the other half, consonant length.

Three native Norwegian speakers (a 54 year-old man, a 54 year-old woman and a 29 year-old man) were given these 36 distinct nonsense words randomized together with similar nonsense words. (The additional words were variations on the basic word type with sonorants substituted for onsets or codas (kaLANta, MApaka, etc.).) Each speaker pronounced each word in isolation and their production of these words were recorded via a headset-mounted microphone. Only the set of long vowel words and the set of geminate words were measured. The duration of each segment was measured using the spectrogram and waveforms produced by Praat version 4.1.27 for Macintosh (Boersma & Weenink 1992–2006), a speech analysis program from the Institute of Phonetic Sciences at the University of Amsterdam.
2.3.2 Classification of data

I measured the vowel length as beginning after the aspiration of the stop release, corresponding to the beginning of the repeated cyclic pattern of the vowel in the sound wave. I counted the right edge of a vowel up until either the onset of the following consonant closure, or, in the case of final vowels, until the cyclic wave form died out, corresponding to a loss of recognizable formants. Consonants were measured for their closure length only: aspiration and release were not included. (A sample labeled spectrogram is given in (9) in §2.4 in conjunction with the subsequent experiment.)

Several things are clear from examining the spectrograms, including that there is increased vowel length under stress (in the absence of a geminate) and that unstressed vowels in word final position are longer than unstressed vowels elsewhere. The spectrograms in (4) show these two observationally clear results.
(4) Spectrograms of vowel lengthening under stress

a. Long vowel in antepenultimate position

b. Long vowel in penultimate position
c. Long vowel in final position

Within the set of words with long vowels, there were 18 tokens each said by three speakers, resulting in 54 words. Each segment was measured and categorized for the syllable it was in (stress level, syllable position, place of articulation of the onset consonant). As each word has three syllables there are 162 cases in the data set. One word spoken by one of the speakers was thrown out, resulting in a loss of three cases. This word was abnormally pronounced with a pause between the first and second syllables, making it look as though the closure of the onset of the second syllable was especially long. Excepting this outlier, the maximum onset closure was 137 ms (with a mean of 86 ms). The rejected word had an onset closure of 341 ms. Therefore, a total of 159 cases were accepted.

We can see from looking at spectrograms of the words with geminates that not only are there word internal geminates, but final geminates exist as well. The spectrograms in (5) show examples of words with a geminate in each syllable position.
(5) Spectrograms of geminates under stress

a. Geminate in antepenultimate position

b. Geminate in penultimate position
c. Geminate in final position

Within the set of words with geminates, there are 18 tokens each said by three speakers, resulting in 54 words and 162 cases, as again each syllable was taken as a separate case. The entire closure of a geminate was counted as part of the rime length of the stressed syllable. This is not an entirely correct assumption since in the case of medial geminates an unknown part of the closure belongs to the following syllable. The entire data set, consisting of the set of words with a long vowel (under stress) and words with a geminate (under stress) contains 321 cases.

2.3.3 Modeling and results

I modeled rime length (vowel or vowel plus geminate length) using a mixed linear model with repeated measures in SPSS 11.0 for Mac. A repeated measures analysis is necessary because multiple measurements come from the same speaker and therefore the observations are not independent. A mixed model, which treats the subjects as a random factor, takes this into account.
A variety of models were examined. We can see that our expectations of the effect of stress and syllable position are borne out. In a model considering stress (two levels) and syllable position (three levels), both factors were significant (F=773.98, F=20.765, respectively; p<0.001). The effects are visually evident in the spectrograms in (4) and (5). The interaction between the two factors is not significant (F=1.792, P=.168), meaning that the effects of stress and position are additive: the effect of one does not offset the effect of the other.

The above model considered only the length of the vowel and any following geminate. It is possible that the release/aspiration of the onset varies under stress and therefore should be included as part of the measurement of the rime length. When we compare a second model in which the dependent variable (DV) is rime length inclusive of onset aspiration with the model with a DV exclusive of aspiration, we find that they are essentially identical. Computing the R^2 for each model we find they are almost the same: .715 exclusive of onset release and .729 inclusive of onset release. There is no meaningful difference between the performance of these models so I will continue to model rime length exclusive of onset release/aspiration.

It is known that only segments in the rime, and not those in the onset, contribute to syllable weight. However, it is possible that onset consonants phonetically lengthen under stress. To test whether this is the case I modeled onset closure duration with the factors ‘stress’ and ‘position’, proved to bear significantly on the duration of the rime. I did not include the words containing a

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^2 The F statistics have decimal places because of the effect of the random factor, ‘subject’.
^3 R^2 is a measurement of the goodness-of-fit of a model. A perfect fit results in an R^2 of 1.0. SPSS does not compute the R-squared for linear mixed models. I am indebted to Barbara Warsavage for these statistics.
geminate in this model because the length of an onset is not determinable when it is part of a geminate. Using the actual closure measurement in these cases would therefore make it appear that onset closure varies with stress, when in fact the increased duration is part of the rime of the preceding syllable. In a repeated measures linear model of onset closure in the words with a long vowel, stress was not significant (F=0.149, p=0.7) and syllable position was marginally significant at the 0.01 level (F=6.285, p=0.014). Since it is evident that onset duration does not vary under stress or with syllable weight (weight correlates exactly with stress here, as all stressed syllables were heavy and all unstressed ones, in this data set, were light), onset duration will not bear further consideration. Henceforth I consider only rime duration.

While we have seen that onset duration does not vary by stress level, it is possible that the place of articulation of the onset could have an effect on the rime’s duration. To test this, I included place of articulation of the onset in the model of rime duration. While the effect of ‘stress’ and ‘position’ was significant, as reported above, the effect of place of articulation of the onset was not (F=0.506, p=0.603). Therefore we can safely disregard the onset when modeling rime duration.

The second question put forth at the outset of this experiment was whether syllables lengthen under secondary stress as well as under primary stress. While syllables bearing secondary stress do not need to be phonologically heavy, there may still be a phonetic effect of lengthening. I again ran a repeated measures linear model of rime length (considering both words with long vowels and those with geminates) with the factors ‘stress’ and ‘position’, but this time the factor
‘stress’ had three levels, zero stress, (potential) secondary stress and primary stress. Words with initial stress were coded as having secondary stress on the final syllable. Words with final stress were coded as having secondary stress on the initial syllable. It is assumed no secondary stress is present in words with stress on the penult, as this would result in a stress clash.\footnote{This means that not every stress level occurs in every position (no secondary stress is possible on the penultimate syllable). In order to run a saturated model I considered only antepenultimate and final position, the two positions where secondary stress may occur in tri-syllabic words.}

While the overall effect of ‘stress’ and ‘position’ were still significant (p<0.001), syllables with secondary stress were not significantly longer than unstressed syllables (p=0.036) and were significantly shorter than stressed syllables (p<0.001).\footnote{These comparisons were done using the parameter estimates in models with different base-lines. The model takes one level of each factor as the baseline and then judges whether changes in the factor levels cause a significant offset from this baseline. Thus two models were run to get these comparisons, one taking unstressed syllables as the baseline, the other taking stressed syllables as the baseline.}

Syllables with (potential) secondary stress are therefore not significantly different from unstressed syllables and these two stress levels may be safely merged. The graph of boxplots in (6) shows that the range of rime duration under secondary stress is not much different from that of unstressed rimes.\footnote{How to read a boxplot: the black line is the median rime length. The data is divided into four quartiles, each of which contain 25\% of the data, discounting outliers that would misrepresent the distribution if included. The box shows the 50\% of rime lengths that are closest to the median, those in the second and third quartiles. The tails of the box plot each show the distribution of the first and fourth 25\%. Outliers are represented with a circle and extreme outliers (none present in (6)) are represented with an asterisk. The number of cases represented in each box plot is noted above the labels on the x-axis.}
In (6) we see that the median rime length in primary stressed syllables is substantially longer than the median rime length in syllables bearing zero stress or secondary stress. While the median rime length under secondary stress is slightly above that for unstressed syllables, this is not a substantial difference and was found not to be significant (at the 0.01 level). I will henceforth consider only two levels of stress, zero stress (unstressed syllables) and primary stress (stressed syllables). While this does not mean that the language lacks secondary stress it does suggest that perhaps the language does not employ secondary stress, at least in three syllable words. Rietveld, Kerkhoff and Gussenhoven (2004), who found lengthening under secondary stress in Dutch, draw the conclusion that the head of a foot lengthens. Phonetic lengthening is a common, if not universal,
correlate of primary stress. If this is also true of secondary stress, the finding here suggests that Norwegian may not exhaustively foot words. This is discussed again in chapter four.

The factor ‘position’ as previously considered has three levels (corresponding to the antepenult, penult, and final). However, the effect of a syllable’s position on the length of a syllable’s rime can be predicted on the basis of whether it is in non-final or final position. While both antepenultimate and penultimate syllables are significantly shorter than final syllables (in both cases, p<0.001), antepenultimate and penultimate syllables are not significantly different from each other (p=0.382). Therefore we may simplify this factor as well, and group non-final syllables together.\footnote{In a model with only two levels of ‘position’, ‘stress’ is significant (F=590.629, P<0.001), as is ‘position’ (F=74.547, p<0.001). The interaction term is not significant (F=0.127, p=0.721).}

The results of the pilot experiment show that stress level and syllable position both influence the duration of the rime. There is evidence that they do not influence the duration of the onset. Nor does the place of articulation of the onset affect the length of the following rime. Further, we have seen that only two levels of ‘stress’ are relevant, unstressed and primary stress; and that only two levels of ‘position’ affect rime length, non-final and final position.

The pilot experiment conducted had several weaknesses. The subjects were all members of the same family which opens the possibility of a family-related difference from the rest of the Norwegian population. Another problem is that the words were pronounced in isolation. Experiment words pronounced in isolation are usually said more slowly and less naturally than test words in a carrier phrase. Additionally, the final syllable was not only word-final but phrase final and utter-
ance final, potentially subjecting it to higher levels of phonetic final lengthening (phrase, utterance, etc.). The measurement of geminates was non-optimal as the length of the entire closure was included in the measurement of the rime. Further, a very limited number of rime shapes were considered: V, V:, and VC:. Considering more rime shapes will allow us to be more secure in the conclusions we draw about the relationship between rime duration and syllable weight.

2.4 Follow-up experiment

The follow-up experiment was undertaken in order to more fully investigate the relationship between stress and rime duration. As discussed at the end of the preceding section, data for a wider variety of rime shapes is needed and the test words need to be spoken in a carrier phrase in order to make the timing of their pronunciation as natural as possible.

2.4.1 Methods

The basic test word remained the same as that used in the pilot, except that the onset consonants in each position were not varied. This was done because the pilot experiment showed no effect of place of articulation of the onset on the duration of the following rime. The test stimuli are given in (7). Capital letters indicate the syllable to be stressed. The stimuli follow regular Norwegian orthographical conventions in which geminates are represented by a double consonant and a long vowel is represented by the absence of a coda in a stressed syllable.
(7) Production experiment stimuli

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Phoneme 1</th>
<th>Phoneme 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV and CV:</td>
<td>KAtapan</td>
<td>KAtapa</td>
</tr>
<tr>
<td>in each position</td>
<td>kaTApän</td>
<td>kaTApä</td>
</tr>
<tr>
<td></td>
<td>kataPAN</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>non-final CV:</td>
<td>KATtapät</td>
<td>KATtapä</td>
</tr>
<tr>
<td></td>
<td>kaTAPpät</td>
<td>kaTAPpä</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVC and CVC:</td>
<td>KANTapat</td>
<td>KANTapa</td>
</tr>
<tr>
<td>in each position</td>
<td>kanTAPät</td>
<td>kantaPAT</td>
</tr>
<tr>
<td></td>
<td>kaTAMpät</td>
<td>kaTAMpä</td>
</tr>
<tr>
<td></td>
<td>KATANpät</td>
<td>katanPÄT</td>
</tr>
<tr>
<td>final CVCC:</td>
<td>kataPATT</td>
<td>kataPAKK</td>
</tr>
<tr>
<td></td>
<td>kataPANK</td>
<td></td>
</tr>
</tbody>
</table>

The words in (7) were made up in order to get samples of all syllable shapes under all possible stress conditions in all possible syllable positions.\(^9\) Note that all combinations are not possible because, for example, CV (with a short vowel) never occurs under stress. Syllable shape CVC cannot occur stressed in final position. (When a final, stressed CVC occurs orthographically it is pronounced CV:C.) And of course the syllable shapes CV:C and CVCC (a final cluster or geminate) can only occur in word-final position, under stress.

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\(^8\)The stress on this token runs counter to a pattern in the stress system of Norwegian as it has a stressed CV penult when the antepenult is heavy, which would usually result in antepenultimate stress. See §4.3.3.1 for more about this pattern.

\(^9\)Final stressed CV, included in the pilot experiment, was excluded here because this is not a stress that is part of a regular pattern in Norwegian, although it does occur exceptionally in some loan words. For more about this stress pattern, see §3.2.1 and §5.3.1. No diphthongs were included as this would cause the static vowel quality to necessarily change, opening up the need to consider vowel quality as a factor in determining rime duration.
These 23 forms were duplicated (so that two copies of every word were in the data set) and randomized for each speaker. There were six additional test words that were in the stimuli set twice each as well. These were four-syllable words based on the basic shape pakatapa but these were not analyzed. This means the stimuli consisted of 58 tokens (29 types, 23 of consequence). These stimuli were placed in the carrier phrase $\text{Æ lige } ____ \text{ og smør}$ (‘I like ____ and butter’, written in Vest-Agder dialect).\textsuperscript{10}

The speakers were four native Norwegian speakers from the Vest-Agder area of southern Norway. The speakers were 25 to 35 years of age and all grew up in the area and had always lived in Norway. (The subjects were a 28 year-old woman (speaker A), a 29 year-old man (speaker B), a 24 year-old woman (speaker C), and a 30 year-old woman (speaker D); none were related.) As part of their instruction before the experiment was run they were given sample stimuli paired with real Norwegian words with corresponding stress. They were also instructed to say the sentence as $\text{Æ lige } [____ \text{ og smør}]$, rather than $\text{Æ lige } [____ \text{... og smør}]$. This was to make sure that the stimuli were not final in a prosodic phrase as this might affect the degree of final lengthening. They were instructed to say each sentence as naturally and fluidly as possible, and to pronounce the stimuli as though they were real Norwegian words. Each speaker was recorded using Praat on a Power-Book G4 saying each sentence into a head-mounted microphone (a Sennheiser PC130) connected to the PowerBook via an iMic. They were encouraged to redo

\textsuperscript{10}One speaker, the first one recorded, instead said $\text{Æ lige } [____ \text{ med smør}$ (‘I like ____ with butter’). I changed the sentence after the first speaker to use $\text{og}$ (‘and’) rather than $\text{med}$ (‘with’) because the following vowel is easier to visually distinguish from the end of the test word than the nasal is. There is no reason to think the change of this word altered pronunciation of the test words.
a sentence they felt did not come out right or which they stressed differently from
the indicated stress. However, they were not corrected if they said a word with
a different stress than was indicated. Although rare, this resulted in having to
throw out a few words from the analysis because they were not spoken with the
indicated stress, or, in one case, because a coda consonant had been omitted.

Nine speakers were recorded but only the data from four were measured and
analyzed. The other five speakers did not consistently manipulate the stress and
pronounced multiple tokens with a different stress than the one indicated by the
capital letters. Their data was excluded from the analysis only because it would
have involved the additional work of recoding each token for which syllable was
actually stressed. There is no reason to think that their actual data differed in
any way. While all Norwegian speakers are presumably competent in the prosodic
phonetics and phonology of their language, not all speakers have the ability to
consciously manipulate stress. For experimental reasons it was easiest to use the
data of those speakers who could produce the indicated stress on each of the
experiment tokens.

2.4.2 Classification of data

As the pilot study found that stress only effects the duration of rime, not onset,
segments, each rime segment in each test word was subsequently measured, based
on the spectrograms, waveforms and auditory track of each sentence in Praat.
The same measuring conventions were used as described for the pilot experiment.
Onset consonants were not measured, nor were the aspiration/release of any con-
Vowel length was measured from the beginning of vowel formants in the spectrogram, corresponding with the beginning of a cyclic pattern in the waveform, to the end of the pattern. Nasals were measured based on their visual differences to other kinds of sounds in a spectrogram. The onset of a nasal consonant is visually clear from an abrupt change in formants, corresponding with a drop in amplitude of the waveform. This is shown in (8).

(8) Onset of nasal corresponding to abrupt change in waveform and formants

The following spectrogram is shown as an example of how segments were parsed for measurement. The added lines through the test word show the determination of segment boundaries.

11 Analysis of the pilot data found that including the release/aspiration of the onset in the measurement of rime duration did not affect the analysis. The closure of stop codas seems to correspond more closely to duration of nasal codas than closure+release does. Therefore the decision was made to exclude all release/aspiration measurements from the measurement of rime duration under the motivated assumption that it is the stop closure timing that contributes to the categorization of the syllable as light or heavy.
Coda consonants that were part of geminates were handled differently than they were in the pilot experiment. Instead of counting the entire consonant closure as part of the rime, only a proportion of the closure was included. The proportion was determined by considering words that had a heterorganic stop cluster across a syllable boundary. Stops are always released in Norwegian and so there is a short release of a heterorganic coda stop before the closure for the following onset. This can be seen in the spectrogram above for [káp.ta.pa], where the [p] in the coda of the antepentultimate syllable is released. Another of the stimuli was [ka.ták.pa]. These cases of a sequence of two stops across a syllable boundary give us a reference for the syllabic distribution of medial geminates. It was found that the coda was 50% of the total stop closure on average in utterances of kaptapa and katakpa. Therefore I recorded the coda portion of a geminate closure as 50% of the total stop closure.
Total rime duration for each syllable was then computed from the individual measurements of the rime segments. In order to control for varying speaking rates, each rime was divided by the length of the entire token. Thus, rather than considering raw rime duration, I looked at each rime’s proportion of the overall word.\textsuperscript{12} I will refer to these as rime/word percentages. Each syllable’s rime/word percentage was coded for stress level (unstressed, stressed), syllable position (non-final, final), and speaker. Only two levels of stress and syllable position were coded because the results of the pilot study showed that three levels were not motivated (see previous section).

As mentioned, words pronounced with a different stress than the one indicated were not analyzed. There were 23 tokens (excluding the four-syllable tokens, which were not analyzed) each said twice by four speakers, resulting in a total of 184 tokens. A native Norwegian speaker (not one of the subjects) with a good ear for stress listened to all the readings and marked those that were not consistent with the indicated stress. These judgments were later verified by the author in the course of examining the spectrograms of the tokens in Praat. Eleven were not measured due to errors.\textsuperscript{13} As each token contains three syllables, each accounts for three cases in the data set. This resulted in 519 cases ((184-11)\times3).

In order to see if any pronunciations were anomalous when compared to the rest of the data, boxplots for each rime size were produced which showed the

\textsuperscript{12}The measurement of the overall word for computing the ratios included all onset closures and releases and word-medial coda releases but did not include any final stop release, as these were often extremely long. Thus the words were measured from the initial onset closure through the final coda closure.

\textsuperscript{13}Speaker A did not misplace any stresses, speaker B misplaced two stresses, left out a coda in one token and lengthened the vowel rather than pronouncing a geminate in two others, speaker C misplaced four, speaker D misplaced two.
distribution of cases broken down by syllable position. Rimes with two segments were further broken down by stress level (not applicable for other rime sizes, since rimes with one rime segment must be unstressed and those with three must be stressed (and final)). Two cases were shown to be extreme outliers, as can be seen from the graph of boxplots in (10), which were both from the same token. (The asterisk below the first boxplot and the one above the third denote the extreme outliers.)

(10) Distribution of rimes with two segments

These two cases were thrown out, as was the one other case that was a measurement from the same token.\textsuperscript{14} The final data set therefore contained 516 cases.

\textsuperscript{14}This was a token from speaker D.
2.4.3 Modeling and results

A repeated measures linear analysis was performed, modeling the rime/word percentage under different levels of stress, in different positions, as shown in the table in (11). As before, ‘subject’ (four levels) was included as a random factor. These choices were informed by the pilot study discussed in §2.3.

(11) Factor levels

<table>
<thead>
<tr>
<th>Fixed Factor</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>stress</td>
<td>unstressed</td>
</tr>
<tr>
<td></td>
<td>stressed</td>
</tr>
<tr>
<td>position</td>
<td>non-final</td>
</tr>
<tr>
<td></td>
<td>final</td>
</tr>
</tbody>
</table>

Both of the fixed factors were found to be significant while the random factor, ‘subject’, was not, as shown in (12). There was no significant interaction between stress and position.

(12) Factor significance

<table>
<thead>
<tr>
<th>Factor</th>
<th>F statistic</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>stress</td>
<td>858.127</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>position</td>
<td>1253.434</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>stress×position</td>
<td>2.634</td>
<td>0.105</td>
</tr>
<tr>
<td>subject(^{15})</td>
<td></td>
<td>0.592</td>
</tr>
</tbody>
</table>

There was not any significant difference between the subjects. This can be seen from the boxplots in (13) where the same pattern is repeated for each subject.

\(^{15}\)There is no F statistic for ‘subject’ because the SPSS linear model only gives F statistics for fixed factors.
Breakdown by subject

a. Rime duration by stress and subject

b. Rime duration by position and subject
We can see that the same pattern is repeated for each subject. While the statistical model was set up to account for the fact that multiple measurements were taken from the same subject, the subjects do not differ in any significant way.\textsuperscript{16}

It can be seen from the boxplot in (14) that stressed syllables are longer than unstressed syllables both non-finally and word-finally, and that all syllables are longer in final position than in a non-final position.

\textsuperscript{16}The model was originally set up with both the subject variable and a repeated variable. The subject variable allows the model to take into account the fact that the residuals are not independently and identically distributed (the normal assumption), since they may vary by subject. (That is, the estimate errors from the measurements taken from a single subject may be correlated.) The repeated variable allows the model to take into account the fact that there may be correlated residuals within the subjects, as each subject was tested multiple times on the same condition. (For example, multiple measurements were taken from each subject for an unstressed non-final syllable. The residuals of the measurements on the same condition, taken from the same person, may be correlated, rather than independently and identically distributed.) However, including the repeated variable nested within subjects did not change anything, and so was excluded from the model reported on in (12).
These results agree with the long-time observation that stressed syllables in Norwegian are long. They also show that there is a strong effect of word-final lengthening, as has been reported in other languages (and is assumed to occur cross-linguistically, see the discussion in §1.3).

As was noted in the pilot experiment, the effects of position and stress are additive. This is shown in (15). The lower portion of each bar reflects the median length of an unstressed rime of size one (CV) in each position. The middle portion shows the increase due to a final consonant (CVC). The upper portion of each bar shows the increase that occurs under stress. In non-final positions that is purely phonetic increase, in final position it is phonological, as the rime will now have three segments.
If we look at rimes of different sizes in final position, as in (16), we see that in non-final positions rimes with two segments are very distinct from those with one segment. This difference in rime/word percentage is repeated in final position not by rimes of one verses two segments, but by rimes of one versus three segments.
The distribution of the boxplots in (16) is an example of the perception effect discussed in the first chapter. The proportional length increase bar chart from chapter one is repeated here in modified form as (17), followed by the graph in (16) turned horizontally to allow a clearer comparison with (17).
In (18), the boxplots for the non-final rime sizes correspond to the first pair of bars in (17). The boxplot showing rimes with one segment in final position corresponds to the first bar in (b) in (17). The boxplot showing rimes of two segments in final position corresponds to the second bar in (b) and the boxplot
showing rimes of three segments in final position corresponds to the third bar in (b).

The distance between rimes of size one and size two is not consistent across syllable position, however, unlike the consistent increase x in the corresponding bars in (17). This is because many of the size two rimes in non-final position are stressed, adding phonetic lengthening (due to stress) to the phonological length. If we replace the non-final rime size two distribution with that of only unstressed non-final rimes of size two the difference between size one and size two rimes in both positions is due only to phonological length, not to phonetic lengthening under stress. This is shown in (19).

(19) rime/word percentage by syllable position and size
Where the units are a rime’s percentage of the entire word, a non-final rime of size two has a median rime/word percentage that is a raw increase of 6.27% over the median for a non-final rime of size one. A final rime of size two has a median rime/word percentage that is a raw increase of 5.23% over the median for a final rime of size one. While the raw increase is almost the same, the proportional increase of a size-two rime is very different in the two positions. I will argue in the following chapter that this explains why a rime of size two is heavy in non-final positions but light word-finally.

2.5 Conclusion

The studies undertaken have shown that there is a sharp contrast in the duration of the rimes of unstressed and stressed syllables. It has long been known that stressed syllables must be heavy in Norwegian and that such syllables usually contrast in weight with unstressed syllables (although non-final CVC syllables are heavy yet may be unstressed). Phonetic correlation of this came out clearly in the results of the study. It is also clear from the study that not only are stressed syllables in final position longer (they contain more segments), unstressed syllables are also significantly longer word-finally. This finding will be used as the basis of the analysis of weight presented in the following chapter. It is shown that in final position CVC syllables are not sufficiently distinct from CV syllables, given the extra length that occurs in word-final position. This is motivation for CVC syllables in final position to behave like CV syllables; that is, to be phonologically light. It is shown that syllables with three segments in the rime, in contrast, are sufficiently distinct from final CV syllables and therefore categorized as heavy.
Chapter 3

The proportional increase theory of weight

3.1 Introduction

Using the results of the experiment set up to measure syllable length in Norwegian, I show that syllable weight can be correctly established through comparison of rime duration. This is a departure from the standard assumption that moras are prosodic entities that segments independently link to. I argue that the proposed weight-determining algorithm is preferable because it does not require stipulation that the right edge is special. I then examine the consequences of the proposed theory of weight for moraic theory, showing that the classical tenets are unaffected, although moras must be considered properties of syllables, not segments. I argue that the view of segmentally-associated moras is problematic and outline a syllable structure that is consistent with the proposed theory of weight and is independently motivated.
3.2 The categorization of syllable weight

As discussed in chapter one, Norwegian is one of many languages with CVC weight asymmetry. The reason for the inconsistent categorization of CVC syllables has not been understood, leading to proposals that single out the right edge, either as a domain of extrametricality or as an inappropriate domain for stress. I propose that the CVC weight asymmetry is perceptually motivated.

Employing the results from the phonetic study presented in chapter two, which allowed measurements of rime duration under various conditions of stress and syllable position, I show that heavy syllables are significantly longer than light syllables in the same position of the word. Comparison must be to a CV in the same position because word-final syllables are significantly lengthened. This means that more length is required word-finally in order to separate a heavy syllable shape from a light one. I show that there is a constant across heavy syllables in all positions: they are at least 60% proportionally longer than an unstressed CV (light) syllable in the same position of the word. This weight criterion does not need to single out final syllables; rather, the fact that CV syllables are much longer in final position (due to the effect of final lengthening) causes a final heavy syllable to be that much longer in order to reach the 60% increase threshold. The fact that a stressed syllable in final position must have three segments in the rime is then explained: the extra length is needed in order for a syllable to reach the 60% increase threshold. The fact that a CVC in final position is light is also explained: such a syllable only represents less than a 30% increase over a CV in final position. As it fails to reach the proportional increase threshold, it fails to count as heavy.
This instantiation of weight disassociates moras from segments, but is argued to be necessary because we cannot say a coda consonant is always moraic. The patch for standard moraic theory is to assume final consonant extrametricality, an unexplained phenomenon. The proposed weight criterion is uniform across syllable positions. The additional segment needed for a word-final syllable to count as heavy is motivated by a perceptual effect: the same increase has less of an effect when the original length was already long. I now turn to the specifics of the proportional increase theory of weight.

3.2.1 Experiment results with respect to syllable weight

All data considered here come from the experiment detailed in §2.4. The rime duration of various syllable shapes in various positions were measured. As stated in chapter two, I measured the rime duration as the percentage of the overall word (rime/word) to control for rate of speech. There are multiple factors contributing to rime duration, all closely related to stress. Here I am interested in predicting phonological weight. A syllable’s weight is almost predictable from considering a combination of rime size and position. Therefore I group syllable shapes by rime size, as shown in (1). The average rime/word percentages by rime size are given in (2).
(1) Syllable shapes by rime size

<table>
<thead>
<tr>
<th>shape</th>
<th>rime size</th>
<th>shape</th>
<th>rime size</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV</td>
<td>1</td>
<td>CV:C</td>
<td>3</td>
</tr>
<tr>
<td>CV:</td>
<td>2</td>
<td>CVC:</td>
<td>3</td>
</tr>
<tr>
<td>CVC</td>
<td>2</td>
<td>CVCC</td>
<td>3</td>
</tr>
<tr>
<td>CVC:</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(2) Average rime/word percentages by rime size

<table>
<thead>
<tr>
<th>size</th>
<th>non-final</th>
<th>final</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.1%</td>
<td>18.7%</td>
</tr>
<tr>
<td>2</td>
<td>15%/19%</td>
<td>22.8%</td>
</tr>
<tr>
<td>3</td>
<td>–</td>
<td>32.5%</td>
</tr>
</tbody>
</table>

Rimes of size two have two difference measurements in non-final position because they may occur unstressed or stressed. While a non-final CVC is heavy, there is additional lengthening under stress, reflected in the greater rime/word percentage of stressed CVC syllables. If a theory correctly categorizes a non-final syllable with a rime/word percentage of 15% as heavy it will clearly categorize one with a rime/word percentage of 19% as heavy as well. Therefore I will consider the unstressed CVC syllables in the following comparisons and leave aside their duration under stress.¹

If we visually compare the rime/word percentages in non-final and final position, we see that, proportionally, the difference between rimes of one versus two

¹I assume speakers categorize weight according to the information available to them. Because rimes containing three segments only surface under stress it cannot be known how much of their duration is due to phonetic effects of stress, beyond their phonological weight. I therefore consider the syllables as speakers must, based on the durations that actually occur.
segments non-finally is paralleled word-finally by rimes of one versus three segments. This is illustrated by the bar graph in (4), which is preceded by a modified version of the general bar graph that was used to illustrate the relation between raw increases and proportional increases in §1.1.

(3)

a. i.  
ii. + x

b. i.  
ii. + x 30% increase
iii. 60 % increase

(4) Rime/word percentage by syllable position and size
As was discussed in chapter one, the same raw increase does not always correspond to the same perceived increase. This is represented generically in (3), where the bars in (a) and the first two bars in (b) are separated by the same raw increase. However, the bars in (a) are more perceptually distinct, both visually, as shown here, and audibly, if heard as sound durations. The same pattern is repeated in (4) with the results from the production experiment with Norwegian speakers reported on in chapter two. We see that there is close to the same raw difference between syllables with one rime segment and those with two regardless of position. However, the two do not have the same perceptual difference across positions. Because single-segment rimes are longer in final position than they are non-finally, two-segment rimes are not perceived to be as distinct in final position as they are non-finally (audibly, although represented here visually). Rimes with three segments, however, clearly contrast with final single-segment rimes, in a way that parallels the two-segment rime contrast with single-segment rimes non-finally.

The basic observation in both (3) and (4) is that a given increase results in a greater perceptual difference at lower/shorter levels and a lesser perceptual difference at higher/longer levels. I suggest that it is this principle of perception that motivates the split between CV and CVX syllables non-finally but between CV/CVC and CVXC syllables word-finally. I do not claim that the light/heavy split is made on the basis of a just-noticable increase, but, rather, is at a proportional increase that makes a particularly good perceptual split. In (5) I schematically show the difference in the average rime/word percentages by syllable size.
with the raw increase over a CV in the same position noted to the right of the bars.

(5) Average rime/word percentages

<table>
<thead>
<tr>
<th></th>
<th>non finally</th>
<th>finally</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV</td>
<td>8.1%</td>
<td>18.7%</td>
</tr>
<tr>
<td>CVC</td>
<td>14.6% +6.5%</td>
<td>23.8% +5.1%</td>
</tr>
<tr>
<td>CVXC</td>
<td>32.5% +13.8%</td>
<td></td>
</tr>
</tbody>
</table>

A CVC syllable is approximately six percent more of the word than a CV syllable, regardless of the position of a syllable. However, because a final CV syllable is so much longer than a non-final CV syllable, the proportional increase of a CVC syllable over a CV syllable in the same position is much greater in a non-final position. While the raw increase of a heavy syllable over a light one varies by position, the (minimal) proportional increase remains constant. The proportional increase of one rime over another is measured as shown in (6).

(6) proportional increase = \( \frac{\text{rime/word}_{\text{same-position CV}} - 1}{\text{rime/word}} \) * 100

The same bars (representing the average rime/word percentages) are given again in (7) but instead of the raw increase, the proportional increase over a CV in the same position is given. An unstressed CV syllable is taken to be the baseline because this is the syllable shape that occurs in every position and is uniformly light.
Non-finally, we see that a heavy (unstressed) syllable is, on average, 80% greater than a non-final CV syllable. We know that non-final CVC syllables are heavy; so clearly an 80% increase is sufficient to be perceived as substantially greater than a non-final light syllable. Word-finally, syllable sizes fall into a pattern we can now interpret. A word-final CVC is only 27% greater than a final CV on average. This falls far short of the 80% increase we see for a CVC in non-final position. Therefore, while a non-final CVC is substantially greater than a CV in the same position, a final CVC is not. I assume that in order for a syllable to be categorized as heavy it must be substantially greater than a CV syllable in the same position. Thus, CVC naturally patterns as heavy non-finally but as light word-finally, based on the syllable shape’s average increase over a CV in the same position. A final CVXC, on the other hand, is 74% greater than a final CV on average. This looks much more like the 80% average increase for a heavy syllable we see non-finally. If we look beyond rime size to actual syllable shapes we see the following proportional increases over a CV in the same position.
All of the increases for syllables that count as heavy are in gray (light and dark). The syllable shape increases marked in light gray are all very similar, and we can assume they represent something like the increase due to more phonological material than a CV. This is particularly clear for non-final CVC syllables, the only shape that occurs both stressed and unstressed in the same position.

The increases marked in dark gray are even larger and are limited to non-final syllables with an underlying coda consonant (that may or may not be part of a geminate). I would like to raise two possible hypotheses for the contrast in proportional increase among non-final syllables. One is that, in addition to the proportional increase in order to meet the weight requirement, stressed syllables are required to contrast with unstressed syllables of the same shape. Thus, a CVː has a lower proportional increase because it contrasts with a CV, but a CVC contrasts with a CVC, a syllable shape that is already heavy, and so additional length would be required in order to make the stress levels contrast. The alternative hypothesis is that phonetic lengthening under stress applies only to
syllables that were underlyingly of a shape that would be categorized as heavy and this phonetic lengthening is not crucial (just as final lengthening regularly occurs but is not known to be crucial). A possible way to differentiate these theories is look at the proportional increase of CV: syllables in known words. The data reflected in (8) comes from pronunciations of novel words and so long vowels are assumed to arise when a syllable would otherwise surface as light and stressed (as discussed in §1.4.2), but known words would be subject to lexicon optimization (Prince & Smolensky 1993), meaning that any long vowels in the surface form would be stored underlyingly. A study of this kind has not been undertaken but a mini-pilot was done in which a native speaker read sentences that each had a real Norwegian noun in a controlled position (neither phrase-final nor sentence-final). It was found that a non-final [í] was 132% greater than [i] in the same position and a non-final [à:] was 146% greater than [a] in the same position.² These numbers seem to pattern with those reported for stressed CVC syllables in (8), rather than with stressed CV: syllables. If we believe that the difference lies in whether or not the long vowel was underlyingly present then the second hypothesis put forward is supported. While further research is needed, I will assume that these results indicate that phonetic lengthening under stress affects syllables that were underlyingly of a shape that would be categorized as heavy and that this phonetic lengthening is not crucially necessary to distinguish stressed syllables (as we see CV: syllables patterning differently depending on their underlyingly form). The fact that non-final CVC: syllables (those closed with a geminate), but not CV: syllables, have a proportional increase similar to non-geminate CVC syllables

²The words that measured [i] were tulipán, dómíno, and albíno, said twice each. Measurements of [a] were taken from papáya, páprika, and ánanas, said twice each.
supports the position taken in §1.4.2 that geminates are present underlyingly and that vowel lengthening is the default method of syllable augmentation.\(^3\)

The only non-CV syllable shape that behaves as light is a final CVC. And, indeed, the proportional increase of a final CVC over a final CV (27%) is markedly different from the increases in gray. The minimum average proportional increase we see for a syllable that behaves as heavy is 71%. Therefore the minimum increase required for a syllable to be categorized as heavy is necessarily greater, we may assume quite a bit greater, than 30% and not more than 71%. The boxplots in (9) show the distribution of proportional increases by syllable shape and position. While the equation in (6) calculates the average proportional increase for a given syllable shape in a given position, the proportional increase of particular tokens was calculated to produce these boxplots. This was done by dividing the rime/word percentage for each rime token by the average CV rime duration in the same position (non-final or final), subtracting 1 in order to get the increase over a CV, and then multiplying the result by 100. The first five boxplots are for non-final rimes, the second five are for final rimes. Both the non-final and final CV rime increases are centered around zero because their average was taken as the baseline that all the rime tokens were compared to.\(^4\) The grayed boxplots belong to syllable shapes that are categorized as heavy (as in (8), darker gray

---

\(^3\)Word-finally, however, there does not appear to be any real difference between the increase of various syllable shapes with three segments in the rime, despite the fact that the hypothesis just outlined predicts that final syllables with a consonant cluster (geminates or not) in the coda should have a greater increase than CV:C rimes. Perhaps phonetic lengthening under stress does not occur (at least to the same degree) in final position, possibly due to the fact that such syllables are subject to phonetic final lengthening, and therefore already subject to phonetic lengthening. Because word-final syllables are affected by final lengthening we can imagine that extra phonetic lengthening for stress is unreasonable or unreachable.

\(^4\)They are not perfectly centered because the tokens were compared to the mean of these rimes whilst the boxplots are centered around the median.
marks syllable shapes that seem to be subject to additional, phonetic lengthening under stress).

(9) Distribution of increases over average rime/word of a same-position CV

Because each syllable shape is compared to the average CV rime/word percentage in the same position, the syllable shapes that are heavy word-finally have a distribution similar to that of non-final heavy syllables although they are much longer. A final CVC, on the other hand, has a distribution that is markedly lower than the heavy syllables. The question of the proportional increase threshold may again be considered in light of the boxplots in (9). We see that the uppermost 75% of heavy syllables falls above approximately 60%, while the top of the tails of light syllable shapes barely reach 60%. I will therefore take 60% to be the proportional increase threshold in Norwegian.
3.2.2 The categorization of syllable weight

A speaker of Norwegian is thought to categorize a syllable as light or heavy based on whether the syllable shape is one that is consistently substantially perceptually greater than a CV syllable in the same position. The evidence from the results of the production experiment suggest that the criterion to be categorized as heavy is a proportional increase of at least 60%.

This proposal raises the question of how weight classification occurs. One possibility is that a syllable’s weight is calculated online for each utterance. In this scenario it is necessary that the proportional increase threshold is reached for every utterance of a heavy syllable, which must be assumed to be compared to previously-calculated and stored average of a CV syllable in the same position. I instead assume that speakers assign weight to a syllable based on their knowledge of whether such a syllable is usually pronounced with a duration that surpasses the proportional increase threshold. The weight of a syllable thus depends on whether the duration of such a syllable regularly sufficiently contrasts with a CV syllable in the same position, not on the duration of a particular utterance of such a syllable. Since the categorization of weight is not done online for each utterance it is impossible for the same syllable shape in the same position to be categorized as light in one utterance and heavy in another, a desirable result. A speaker of Norwegian knows from experience whether a given syllable shape in a given position is light or heavy. The calculated categorization of syllable shapes in non-final and final positions is given in (10). The calculation of syllable weight based on the proportional increase threshold is thought to reflect whether or not
the duration of a syllable sufficiently contrasts perceptually with an unstressed CV in the same position.

(10) Proportional increase and associated phonological weight

<table>
<thead>
<tr>
<th></th>
<th>increase over same-position CV</th>
<th>at least 60% increase?</th>
<th>phonological weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>non</td>
<td>CV 0%</td>
<td>no</td>
<td>µ</td>
</tr>
<tr>
<td>final</td>
<td>CV: 88%</td>
<td>yes</td>
<td>µµ</td>
</tr>
<tr>
<td></td>
<td>CVC 80% (162%)</td>
<td>yes</td>
<td>µµ</td>
</tr>
<tr>
<td>word</td>
<td>CV 0%</td>
<td>no</td>
<td>µ</td>
</tr>
<tr>
<td>final</td>
<td>CVC 27%</td>
<td>no</td>
<td>µ</td>
</tr>
<tr>
<td></td>
<td>CV:C 68%</td>
<td>yes</td>
<td>µµ</td>
</tr>
<tr>
<td></td>
<td>CVC: 74%</td>
<td>yes</td>
<td>µµ</td>
</tr>
<tr>
<td></td>
<td>CVCC 74%</td>
<td>yes</td>
<td>µµ</td>
</tr>
</tbody>
</table>

There are two syllable types absent from the categorization table in (10): diphthongs (non-final and final) and a long vowel in an open syllable word-finally. These syllable types were not included in the production experiment but I discuss them in turn and argue we can categorize their weight from known facts.

Stressed syllables in Norwegian must be heavy. The fact that non-final and final CVV syllables may bear stress unaugmented strongly suggests they are heavy. It is straightforward to categorize non-final diphthongs as heavy since a long vowel surpasses the proportional increase threshold and a diphthong would presumably have a similar duration. The conclusion that final diphthongs are also categorized as heavy is more interesting since we have previously only seen final heavy syllables with three rime segments. Words from the lexicon of Norwegian with stressed diphthongs are given in (11).
Diphthongs are heavy in non-final and final position

<table>
<thead>
<tr>
<th></th>
<th>non-final</th>
<th>final</th>
</tr>
</thead>
<tbody>
<tr>
<td>fáuna</td>
<td>‘fauna’</td>
<td>levkóy ‘matthiola’ [kind of flower]</td>
</tr>
<tr>
<td>balaláika [Russian string instrument]</td>
<td>kakáo ‘cocoa’</td>
<td></td>
</tr>
<tr>
<td>bóykott ‘boycott’</td>
<td>samurái ‘samurai’</td>
<td></td>
</tr>
<tr>
<td>kláusul ‘clause’</td>
<td>Paraguáy ‘Paraguay’</td>
<td></td>
</tr>
</tbody>
</table>

Vowels are generally longer than consonants so, although a CVV has only two rime segments, it may be assumed, at least until experimental evidence is available, that a sequence of two vowels word-finally meets the proportional increase threshold even while another two-segment rime shape, CVC, does not.

While the main production experiment did not include any final stressed open syllables, the pilot study did include final stressed CV syllables. The duration of the vowel was lengthened considerably as can be seen from the spectrograms in (4) in chapter two and from the box plots below. The unit along the y-axis is raw rime length (in seconds), as rimes in the pilot experiment were not measured as a percentage of the overall word.
It is clear from comparison of the spectrograms in chapter two and from the box plots in (12) that word-final long vowels are substantially longer under stress. This leads us to expect that long vowels and diphthongs (as they are both a sequence of two vowels) in final open syllables are heavy. While there is evidence to back up this conclusion for final diphthongs (given that such syllables occur stressed word-finally) there is not sufficient evidence to draw this conclusion for long vowels.

Norwegian does allow a final stressed CV: syllable in some instances, namely monosyllabic words (e.g. få ‘get’, by ‘city’) and in French loan words with final stress (e.g. kopi ‘copy’, obo ‘oboe’). These are usually taken to be long final
vowels, and as we know stressed syllables must be heavy, this would seem to enlarge the inventory of final heavy syllables to include CV:

A problem with this assumption is that we know final stress is usually avoided when the final syllable is an open monothong. The examples cited in the previous paragraph are exceptions, not part of the basic pattern of Norwegian stress. The exceptions fall into predictable classes: words that have no other syllable to stress and loan words that preserve their original stress. Further, a second production experiment, described and discussed in chapter four, asked Norwegian speakers to read sentences containing a novel noun. Their placement of stress on the novel words were recorded and it was found that CV-final words overwhelmingly received non-final stress. This is shown in the bar graph in (13).

(13) Speakers placement of stress on novel CV-final words

![Bar Graph](image-url)
Out of 338 tokens only 24 were given final stress. As will be demonstrated in chapter four, stress is always at the right edge as long as the syllable is heavy. The fact that we do not find final stress when the final syllable may be augmented to CV: shows that a final CV: is light, not heavy.

We are left with the question, then, of why a final diphthong (CVV) should be categorized as heavy when a final long vowel is not. I suggest that it is not because they necessarily differ in whether they meet the proportional increase threshold. As was shown in (12), final stressed vowels are substantially longer than final unstressed vowels, and may well reach the proportional increase threshold. Rather, I suggest, the lightness of final CV: is due to the fact that it is difficult to perceive vowel length contrasts word-finally. Many languages with phonemic vowel length neutralize it in final position because final lengthening as well as the tendency to partially devoice word-final segments make a contrast difficult to perceive (Myers & Hansen forthcoming, 2005). While Norwegian does not have a true vowel length contrast since length is dependent on stress (as discussed in §1.4.2) I propose that no vocalic length difference is perceived word-finally regardless of the stress level. I have not undertaken a perception study of final vowel length with Norwegian speakers, but in informally asking native speakers, who are normally conscious of vowel length, I have found that they were in fact unsure whether final stressed vowels (as in fā and obo) were long or short. If there is no perceived vowel length difference word-finally it explains why we do not find final stressed vowels patterning as heavy: additional word-final vowel length is not parsed as a phonologically long vowel. So while a final stressed CV(:) may well

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5Myers and Hansen argue that in languages with final vowel length neutralization word-final vowels are categorized as short because final devoicing makes their length less perceivable.
surpass the proportional increase threshold, a long word-final vowel is too blurred by final lengthening and possibly final devoicing to be perceived as distinct from a final CV. A final CVV does not fall victim to this perceptual problem because the change in vowel quality signals its phonological content.

A proportional increase of at least 60% is usually adequate to make a syllable sufficiently perceptually distinct from a CV syllable in the same position. However, this is argued not to be the case for word-final open monothong syllables. Although a final stressed CV syllable is markedly longer than an unstressed one (see (12)), it is argued that a vowel length contrast is not perceived. This relies on the assumption that increased phonological content must accompany the proportional increase of a heavy syllable over a same-position CV syllable. A phonetic prolongation is not sufficient.

An abbreviated version of the categorization of syllable weight from (10) is given in (14), showing only the syllable shape and position and its phonological weight. This phonological weight is calculated as was shown in detail in (10): on the basis of whether or not it surpasses the proportional increase threshold of 60%. Diphthongs, which have been argued to meet the proportional weight criterion, are included in this chart. Final long vowels are excluded, as it has been argued that there is no perceived vowel length difference word-finally.
3.2.3 Conclusion

The proportional increase theory of weight has been shown to motivate the CVC weight asymmetry present in Norwegian. This proposal is an improvement over final consonant extrametricality both because it is perceptually motivated and because it does not single out the final position in any way. Rather than discounting the final consonant, as extrametricality does, the proposed analysis shows that the extra duration due to the final consonant is necessary for a final syllable to be as perceptually distinct from a same-position CV as heavy syllables are non-finally.

While the production experiment did not include words with final diphthongs it is assumed that a final diphthong meets the proportional increase threshold, although this should be verified through future experiments. Word-final stressed CV syllables are rare and, while their length presumably reaches the proportional increase threshold, are nevertheless considered light because phonological vowel length is argued not to be perceived word-finally. A final diphthong or final closed
syllable, on the other hand, has a change of quality from the vowel to indicate its phonological content beyond a single vowel.

This proportional increase of theory of weight determines the weight of a particular syllable shape for the rime as a whole. A particular syllable shape is categorized as heavy if its rime is, on average, at least 60% longer than a CV syllable in the same position and is categorized as light otherwise. Standard moraic theory, on the other hand, takes moras to be associated with individual segments in the rime. In the following section I discuss the consequences of the proportional increase theory of weight for moraic theory.

3.3 Consequences for moraic theory

I have argued for a categorization of syllable weight that does not take moras to be independent prosodic units, but rather a property of syllables. I show generic examples of the proposed syllable structure in (15). (The “C” and “V” nodes stand in for the collective features that make up a consonant or vowel, respectively, assumed to be headed by a root node. The internal structure of segments is not shown except in the representation of long segments. Non-root features, when shown separately from the root node, are represented collectively by a capital letter.)
This syllable structure differs from that assumed by standard moraic theory in that it lacks a moraic tier and includes onset and rime nodes. Segmental length is represented directly by the presence of a root node; a long vowel or geminate results from the sequence of two adjacent identical root nodes that dominate identical features. The syllable’s weight, determined by the weight criterion, based on the proportional increase theory of weight, is notated as a subscript on the syllable node.

The classification of syllable weight argued for is consistent with moraic theory to a point, but is incompatible with several claims of standard moraic theory. I state the claims of moraic theory in §3.3.1, highlighting those that are consistent with the proposed categorization of syllable weight and those that are not. I then examine the conflicting claims in §3.3.2 and §3.3.3, show that there are other reasons why they are problematic, and propose an alternative.

3.3.1 The claims of moraic theory

Moraic theory, at its core, makes several claims.
Classical moraic theory

1. **Binarity**: There is a binary distinction between light and heavy syllables.

2. **Quantity sensitivity**: Prosodic processes are sensitive to syllable weight, not to segments.

3. **Moraic equivalence**: Syllables of different shapes but belonging to the same weight class pattern together.

These basic tenets of moraic theory originate in classical Latin and Greek metrics, are kept in standard moraic theory (Hyman 1985, McCarthy & Prince 1986, Hayes 1989), and are not disputed here.

Standard moraic theory makes several additional claims.

1. **Moraic status**: Weight-bearing segments are associated with a mora.

2. **Moraic distinction**: Segment length is encoded by moraic association.

The first claim, that moras have the status of prosodic constituents and are associated directly to segments, leads to the necessity of assuming final-consonant extrametricality or NonFinality for languages with CVC weight asymmetry. I have argued that the proportional increase theory of weight is preferable to both of these approaches. However, a theoretical consequence of determining syllable weight as proposed is that moras cannot be taken to be associated to individual segments. This affects both the claims in (17), as if the first claim does not hold then there can be no distinction made between segments on the basis of whether or not they are associated with a mora. I consider these claims in turn.
3.3.2 Moras as properties of syllables versus segments

Taking moras to be associated with individual segments does not always lead to the correct prediction of syllable weight. This has been extensively discussed in chapter one in relation to the CVC weight asymmetry. Segmentally-associated moras have been taken to be a unit of tone association (e.g. Hyman 1985). However, Zhang (2002) has demonstrated that tone association does not match up to the mora count of a syllable, even in languages in which tones had been thought to associate with individual moras. He shows, for example, that contour tones are allowed on word final syllables that are not allowed non-finally. The additional length in final position due to final lengthening enables more tones to occur on the syllable. This cannot be due to additional moras since the syllables in final position behave differently than syllables of the same shape in non-final positions. Zhang therefore argues that tones are sensitive to the phonetic duration of a syllable and that the mora is not an appropriate unit for tone association.

One argument in favor of taking moras to associate directly with segments is that it provides a natural division between segments that contribute to the weight of the syllable (segments in the rime) and those that do not contribute to a syllable’s weight (segments in the onset). However, if moras are real prosodic units and not just a theoretical notation we should be able to determine whether a segment is associated with a mora, two moras, or a shared mora. In fact, looking at the basic structure of a heavy CVCC syllable it is not clear what the moraic associations are. Given the assumption that only weight-contributing segments may be dominated by moras, two possibilities are shown in (18).
The mora-associations in both (a) and (b) are somewhat unsatisfying. In (a), a rime segment (in a language that clearly treats codas as weight-contributing) is not associated with a mora. While all weight-contributing segments are associated with a mora in (b), the structure seems to be predicting that the vowel, with a mora to itself, has a different status than the coda consonants, which share a mora. And yet, in a heavy CVC syllable, the coda consonant will bear its own mora. The proportional increase theory of weight does not have this asymmetry between weight-contributing segments because (the duration of) all such segments contribute to the categorization of the syllable as light or heavy.

Further, there are proposals that place onsets under a shared mora, as in Hyman (1985), Zec (1988), and Hayes (1995). Thus, the theory has not distinguished the two structures in (19).

The status of moras with respect to onsets
While it is problematic to decide how to associate moras with segments, it can be demonstrated that a particular syllable shape is either light (monomoraic) or heavy (bimoraic). The proportional increase theory of weight does exactly this, with no individual association between the weight-contributing segments and the moras. Thus, the concern of whether, for example, a third rime segment is dominated by a shared mora or not becomes moot.

In order to group weight-contributing segments, I assume syllabic structure of an onset and rime node, where the weight-contributing segments are parsed into the rime node.\footnote{The split of onset and rime is sufficient for my purpose here, but in a language that treats CVC as light lower levels of the rime (nucleus, coda) will be relevant as only the nucleus contains weight-contributing segments.}

(20) Syllable structure (e.g. Fudge 1987)

\[\begin{tikzpicture}
  \node (root) {\(\sigma_{\mu(\mu)}\)};
  \node (onset) [below left of=root] {onset};
  \node (rime) [below right of=root] {rime};
  \draw (root) -- (onset) node [midway, left] {C};
  \draw (root) -- (rime) node [midway, right] {VC};
\end{tikzpicture}\]

The segments that contribute to syllable weight may be identified by locating the sonorant peak of the syllable as this will be the syllable nucleus.\footnote{I do not detail the process of parsing syllabic structure but see, for example, Zec (1988), Clements (1990), and the notion of harmonic alignment in Prince and Smolensky (1993).} Note that, given richness of the base, the grammar must also be able to identify the weight-contributing segments under standard moraic theory assumptions. Standard moraic theory relies on the grammar to correctly assign moras to segments that are in mora-bearing positions but are underlyingly mora-less.\footnote{Bermúdez-Otero (2001) and Campos-Astorkiza (2004) argue that \(\text{Dep}_\mu\) should not penalize epenthesized moras for underlying segments that are in a weight-bearing position, showing that it is problematic if the constraint does. Under the theory of weight proposed here there are no faithfulness constraints relativized to moras, avoiding such issues.} Here, such
segments identified by the grammar are taken to be dominated by a rime node, uniting those segments that contribute to the weight-determining algorithm.

Assuming a rime node also gives us an option for capturing compensatory lengthening other than the moraic theory analysis put forth by Hayes (1989). Under the analysis presented by Hayes, when a coda consonant associated with a mora deletes, the preceding vowel will associate to the mora that was left behind. The lengthening is motivated by mora preservation and explains why we do not find lengthening in response to onset deletion. Given the proposed weight criterion in which weight is a property of syllables, not segments, we could see compensatory lengthening as weight preservation of the syllable. (Also see Kavitskaya (2002) for phonetic accounts of compensatory lengthening that cast doubt on an autosegmental analysis of weight.)

3.3.3 Inherent versus derived length

Under standard moraic theory, geminates are consonants that have an underlying mora, as shown in (21). I will refer to this as the geminate-weight hypothesis.

(21) A geminate in moraic theory (the geminate-weight hypothesis)

\[
\mu \\
| \\
C
\]
Under the geminate-weight hypothesis, length is a consequence of weight.\textsuperscript{9} A moraic consonant is not necessarily long, however; it will only be realized as a geminate if the structure of the word requires consonantal length.

\begin{enumerate}
\item Moraic consonants
\begin{itemize}
\item a. singleton coda
\begin{tikzpicture}[scale=0.5]

\node (root) at (0,0) {$\sigma$};
\node (first) at (-1,1) {$\mu$};
\node (second) at (1,1) {$\mu$};
\node (third) at (0,2) {$\sigma$};
\node (fourth) at (-1,3) {$\mu$};
\node (fifth) at (1,3) {$\mu$};
\node (sixth) at (0,4) {$\mu$};
\node (first syllable) at (-1,5) {$C V C$};
\node (second syllable) at (1,5) {$C V$};

\draw (root) -- (first);
\draw (root) -- (second);
\draw (third) -- (fourth);
\draw (third) -- (fifth);
\draw (third) -- (sixth);
\draw (fourth) -- (first syllable);
\draw (fifth) -- (second syllable);
\end{tikzpicture}
\item b. geminate coda
\begin{tikzpicture}[scale=0.5]

\node (root) at (0,0) {$\sigma$};
\node (first) at (-1,1) {$\mu$};
\node (second) at (1,1) {$\mu$};
\node (third) at (0,2) {$\sigma$};
\node (fourth) at (-1,3) {$\mu$};
\node (fifth) at (1,3) {$\mu$};
\node (sixth) at (0,4) {$\mu$};
\node (first syllable) at (-1,5) {$C V C$};
\node (second syllable) at (1,5) {$C V$};

\draw (root) -- (first);
\draw (root) -- (second);
\draw (third) -- (fourth);
\draw (third) -- (fifth);
\draw (third) -- (sixth);
\draw (fourth) -- (first syllable);
\draw (fifth) -- (second syllable);
\end{tikzpicture}
\end{itemize}
\end{enumerate}

The moraic consonant in (a) is realized as a singleton whereas the moraic consonant in (b) is realized as a geminate. This is due to whether or not there is a following consonant. If there is not, the moraic consonant will lengthen to fill the onset of the following syllable, as well as serving as the coda of the syllable that contains its mora. However, this is not sufficient to predict gemination as we also find geminates in words like \textit{febbre} (‘fever’) in Italian where the consonant is geminated although there is a following consonant. Rather, the geminate-weight hypothesis predicts that we should find syllabification contrasts like hypothetical \textit{feb.re} and \textit{fe.bre}, based on whether or not \textit{[b]} is moraic (Armin Mester, p.c.). It is well-known that languages do not contrast syllabification and so this prediction is not borne out.

\textsuperscript{9}Ham (2001) finds that coda geminates are longer than onset geminates. This has been taken as phonetic evidence for the mora as a segmental unit of weight (Cohn 2003). However, it may also be attributed to a difference between the phonetic realization of segments in the onset and those in the rime.
This minimal specification of geminates, as proposed by Hayes (1989), is consistent with the principle of lexical minimality, a tenet of underspecification theory (Stanley 1967, Chomsky & Halle 1968, Archangeli 1988, et al.). Lexical minimality assumes that only the minimum phonological information necessary to distinguish words is present underlyingly. Other features are predictable and so do not need to be specified underlyingly, although they are present in the surface form (principle of full specification). Thus, geminates are minimally specified as mora-bearing, and their length is assumed to be derivable. However, underspecification has lost its power within optimality theory (OT) (Prince & Smolensky 1993) as there are no phonological conditions on inputs (richness of the base means that the grammar must be able to deal with fully specified inputs). Smolensky (1993) shows many processes that had previously been analyzed with reference to underspecification can be reanalyzed within OT where markedness constraints play the crucial role. Inkelas (1994) and Artstein (1998) show that given the structure of OT, an output cannot be more marked than its input. It can be as marked, where markedness in the input is preserved due to faithfulness constraints, or it can be less marked, due to markedness constraints. This means that underspecification is usually not useful since it can only be assumed for alternations of unmarked structure. Given the representation of a geminate as an underlyingly mora-bearing consonant, the constraint Onset (which requires that all syllables have an onset) is relied on to force phonological length on the surface. However, if the markedness constraint against long segments/geminates is ranked above Onset, the predicted lengthening will not occur. This is shown in (23).

10 I thank Armin Mester for pointing out the connection between the geminate-weight hypothesis and underspecification theory.
(The constraint \textsc{MaxLink}_\mu requires that underlying segmental links to moras must be preserved.) The notation in candidate (c) represents consonantal length, split across two syllables.

(23)

<table>
<thead>
<tr>
<th></th>
<th>/CVC_\mu V/</th>
<th>\textsc{MaxLink}_\mu</th>
<th><em>\textsc{Geminate}/</em>\textsc{Long}</th>
<th>\textsc{Onset}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>CVC_\mu V</td>
<td></td>
<td></td>
<td>*!</td>
</tr>
<tr>
<td>b.</td>
<td>CV.CV</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>CVC_\mu:.V</td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Under this ranking, the cross-linguistically dispreferred form, candidate (a), is in fact optimal. This is a problem, since an intervocalic consonant is always syllabified as an onset, not a coda. In fact, one of Hyman’s (1985) motivations for moraic structure was to prevent such a form from being predicted. We see from (23), however, that an intervocalic moraic consonant is not always forced to geminate in OT.

There are multiple reasons to think that geminates should be represented with underlyingly length. First, their representation in standard moraic theory relegated phonological length to a reflex of their moraic status and the constraint \textsc{Onset}. This denies geminates inherent length, although duration is the primary perceptual distinction between geminates and singleton consonants (Lahiri & Hankamer 1988, Hankamer, Lahiri & Koreman 1989, Abramson 1999). Second, as I have shown, nothing ensures that intervocalic moraic consonants do, in fact, surface as geminates. Third, the representation of initial and final geminates is problematic for standard moraic theory, since even if the segment is weight-contributing there is nothing to force consonantal length (gemination).
Finally, there have been many arguments in the literature for inherent geminate length, based the fact that geminates do not always behave as heavy. Vago (1992) and Ringen and Vago (2002) discuss cases where geminates pattern with consonant clusters rather than with (other) moraic segments with respect to quantity sensitive processes. Selkirk (1990) and Tranel (1991) express skepticism of the geminate-weight hypothesis prediction that all geminate codas are weight-contributing, especially in languages where CVC is light. Although Davis (1994), for example, presents two languages, Hindi and Korean, in which CVC syllables are light but syllables closed by geminates as heavy, Curtis (2003) shows that these data are subject to reanalysis. Curtis, after an extensive study of geminates and language systems that have geminates, concludes that geminates must be represented with inherent length.

A consequence of the proportional increase theory of weight is that geminates cannot be represented as moraic consonants because moras are properties of syllables, not segments. However, I propose that this is not a problem for the theory because, as discussed above, there is reason to believe that geminates are better represented as inherently long, rather than as inherently weight-bearing. In the following section I propose a compositional representation of length.

### 3.3.3.1 Representing length

Prior to standard moraic theory, length was represented in a timing tier, as illustrated in (24) for a word-final geminate coda, where “C” and “V” stand in for segments. In the skeletal slot model a geminate is a consonant linked to two timing slots.
There have been many criticisms against skeletal slots. The work of McCarthy and Prince (1986) showed that morphological templates in languages do not have a certain number of slots, but rather are prosodic constituents such as syllables. (See Broselow (1995) for a summary of the history skeletal slots and moraic theory.) Skeletal slots have been considered obsolete at least since Hayes’ (1989) demonstration that standard moraic theory is able to predict the attested typology of compensatory lengthening, while segmental prosodic slots are not, thereby motivating the replacement of the timing-slot tier with a moraic tier. While timing slots allow us to represent segmental length we do not want to add an additional tier that does not contribute anything further to the theory.

Segments themselves already denote singleton length, and two identical segments in a row will result in a phonologically long segment. The assumption that segments have inherent (singleton) length must be assumed under standard moraic theory as weightless consonants, such as onsets, must have (singleton) length. A onset cluster, as a sequence of two weightless segments, will be longer than a single onset consonant. If there were two adjacent identical segments such a sequence would be realized (with no further assumptions) as a long vowel or a geminate. A segment’s features are assumed to be headed by a root node which contains the major class features (Schein & Steriade 1986, McCarthy 1988).
It is usually assumed that adjacent identical segments are marked, and that adjacent segments with the same value of a feature will share that feature. I therefore borrow from Selkirk (1990) the idea that adjacent identical root nodes may occur, and, when they share all other features, represent a long vowel or geminate. This idea has seen a recent revival in the literature (see, for example, Ringen & Vago 2002 and Curtis 2003). My proposal differs from Selkirk’s because I do not also assume a moraic tier. This is shown in (25) for a sonorant geminate, but represents the assumed structure of phonological length generally. Capital letters represent all features below the root node. (While an onset and rime node are assumed, they are not shown here.)

(25) Compositional representation of length

\[
\begin{array}{c}
\sigma \\
\text{[A]} \\
\text{[B]} \\
\text{[C]}
\end{array}
\]

The representation of length illustrated above is consistent with the standard assumptions that, first, a sequence of two segments is longer than a single segment, and secondly, that adjacent identical features are shared. While we see all features (representationally) being shared by the geminate in (25), it is standard to assume that adjacent root nodes share features they have in common (for example, it is common for codas to share the place features of the following onset (the Coda Condition of Ito 1986)). The root nodes are not assumed to have any prosodic status. On the (standardly necessary, but generally unspoken) assumption that
every segment, headed by a root node, contributes length, the compositional representation of length allows us to capture long vowels and geminates.

It was shown in (23) in §3.3.3 that the geminate-weight hypothesis incorrectly predicts that an intervocalic moraic consonant may surface as only a coda. The proposed representational theory of length instead predicts that such a candidate will never surface, as it can be seen in (26) to be harmonically bounded. Generic “C” and “V” are used to represent consonantal and vocalic root nodes. Further features, where relevant, are again represented by capital letters.

(26) CVC.C parsing harmonically bounded

<table>
<thead>
<tr>
<th>/C V C C V/</th>
<th>Max</th>
<th>*GEMINATE/*LONG</th>
<th>Onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. CVC.V</td>
<td>*</td>
<td></td>
<td>⬠!</td>
</tr>
<tr>
<td>b. CV.CV</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. C V C C V</td>
<td></td>
<td></td>
<td>⬠*</td>
</tr>
</tbody>
</table>

Because candidate (a) incurs more violations than the other candidates it will never surface, regardless of the constraint ranking, a desirable theoretical result.

### 3.4 Conclusion

The proportional increase theory of weight has been proposed as a weight-determining criterion and shown to correctly predict syllable weight in Norwegian. The weight of a given syllable shape in a particular position is determined based on the relationship between the duration of the syllable’s rime and that of a CV syllable
in the same position (corrected for speaking rate). If a (corrected) rime is at least 60% greater than that of a CV in the same position, the syllable is categorized as heavy. If the proportional increase of a syllable does not reach this threshold then the syllable is categorized as light. This weight-determining algorithm accounts naturally for the CVC weight asymmetry. A non-final CVC was shown to surpass the proportional increase threshold, whereas a final CVC fell notably short of it. This difference is due to the fact that a final CV is markedly longer due to final lengthening. Therefore, additional length, beyond that added by a final consonant, is needed in order for a rime’s duration to increase 60%.

The proposed theory has been argued to be superior to the approach taken within standard moraic theory, which assumes segmentally-associated moras and final consonant extrametricality. The proposed weight criterion is perceptually motivated and does not need to refer specifically to the final position. While the effectiveness of the proportional increase theory of weight needs to be investigated for other languages traditionally analyzed with final consonant extrametricality, the results shown for Norwegian are very promising.

Further, the proportional increase theory of weight explains another fact about CVC weight asymmetry that is well known: that this asymmetry is between non-final positions and final position. Though there are some cases where extrametricality has been claimed to be needed word-initially, extrametricality is overwhelmingly claimed for word-final, not word-initial, constituents. The limitation of the CVC weight asymmetry to non-final versus final position is explained in the proposed theory, as the word-level domain of final lengthening is the final
rime. Extrametricality, on the other hand, should be able to apply at either word edge and its initial/final asymmetry is unexplained.

It is a consequence of the proportional increase theory of weight that moras must be taken to be properties of syllables, rather than of individual segments. While this is not at odds with the tenets and insights of classical moraic theory, it is inconsistent with standard moraic theory since there is no longer a moraic tier. I have argued that there are problems with taking moras to be associated with segments, especially with respect to the geminate-weight hypothesis.

In order to unite the weight-contributing segments in a syllable, I assume that a rime node is present and such segments are identified in the same way mora-bearing segments would be identified from a mora-less input under standard moraic theory. I further assume the compositional representation of segmental length, as illustrated in (25) in the previous section, which has the advantage that it takes the length of geminates to be inherently represented by a sequence of adjacent identical root nodes that dominate identical features. This builds on inherent segmental length: a root node with associated features contributes (singleton) length.
Chapter 4

An OT analysis of the basic Norwegian stress pattern

4.1 Introduction

In this chapter I propose and support an analysis of Norwegian stress that assumes the categorization of syllable weight advanced in chapter three. The foundations of the analysis are identified and discussed in §4.2. These include a novel word experiment that was undertaken to investigate speakers’ placement of stress on words of different shapes. The results of this experiment provided support and further evidence for the analysis of stress proposed here, consisting of a basic pattern (previewed in §1.4.4) and of minor stress patterns, that is, predictable exceptions to the basic pattern. Exceptions to the basic pattern are examined in chapter five, where it is shown that the experiment results allow us to separate minor stress patterns from truly exceptional stress. An optimality theoretic analysis of the basic stress pattern, supported by the lexicon and the results of the novel
word experiment, is given in §4.3. (Relevant background about Norwegian was given in §1.4). The analysis proposed here differs in several interesting ways from previous proposals and a comparison of analyses is made in §4.4, the conclusion.

4.2 Analysis foundations

The two major sources for the proposed analysis of stress were the Norwegian lexicon and the results of a novel word experiment. Each of these sources in introduced in turn. In §4.3.1 I lay the foundation for an analysis of Norwegian stress in optimality theory, showing how long vowels and geminates may be restricted to stressed syllables and how lengthening of the vowel is predicted if a syllable would otherwise surface as stressed and light.

4.2.1 Evidence from the lexicon

The traditional cornerstone for an analysis of the stress pattern of a language is evidence from the language’s lexicon. My main source was a database compiled by Gjert Kristoffersen which he very kindly and graciously shared with me. Kristoffersen compiled this database of words of at least two syllables mostly from the A–K listings in a loan word dictionary (Selmer 1966). He was careful to include only monomorphemic words (Kristoffersen 2000: 150, especially fn. 16, 17). The majority of these words are nouns, and while I too focus my attention on nouns, the proposed analysis extends to other lexical categories as well. I have checked all of the words I use as examples with a native Norwegian speaker, both for stress and for vowel and consonant length, the latter of which is unmarked in the
database. Only loan words are considered because, as discussed in §1.4.3, native words are either monosyllabic or of the shape CVX.Cσ, so stress is unvaryingly initial. The analysis presented here is consistent with this stress pattern and so native words do not need to be considered further.

My study of the Norwegian lexicon found that the basic stress pattern is as enumerated in (1).

(1) Basic stress pattern

1. Consonant-final words receive final stress (e.g. elefánt, tulipán)

2. Stress is otherwise penultimate (e.g. mango, láma)

3. Unless the penult is light and the antepenult is heavy, in which case stress is antepenultimate (e.g. índigo, brókkoli)

There are numerous exceptions to this pattern. I identified the following subgroupings.

(2) Exceptional patterns

- Penultimate stress on [s]-final words (e.g. aspárges, kó:kos)

- Penultimate stress on [Cs]-final words (e.g. bó:ra:k, há:ubits)

- Penultimate stress on [er]/[et]-final words (e.g. kaní:ster, kalí:ber)

- Antepenultimate stress on V-final, final hiatus words (e.g. fó:lie, abrá:siø)

- Final stress on vowel-final French and Greek loan words (e.g. orkí:ðé, kopí)
In chapter five I argue that all but the final subgroup in (2) constitute minor stress patterns. While such words do not follow the basic stress pattern, they form groups of predictable exceptions, identified by their shape. The words in the final subgroup are not part of a minor pattern as words in this group have no identifying shape that a speaker could use as the basis for forming a minor pattern. The existence of minor stress patterns for the first four subgroupings, and the absence of a minor pattern for the last, was supported by the results of the novel word experiment.

4.2.2 Evidence from novel words

The second source for the proposed analysis of the stress system of Norwegian is the results of a novel word experiment. The subjects were thirty-nine native speakers, aged 12–29. They were almost exclusively speakers of the Vest-Agder dialect although a few came from other areas of the country. The stress placements by speakers from other parts of the country were not noticeably different from the majority and, as noted in §1.4, the stress pattern is thought to be consistent across dialects of Norwegian (although the position of stress in a few individual words does vary). Subjects were given printed lists of sentences that each contained a novel word. The same novel words and sentence frames were used for each subject, but randomized for each, both in respect to which novel word was in which sentence frame and to the overall order of the sentences. The subjects were then asked to read the sentences out loud, pronouncing any unknown words as naturally as possible, as if they were Norwegian words. Subjects wore a head-mounted microphone (a Sennheiser PC130) connected to a PowerBook via an
iMic and I recorded them using Praat (Boersma & Weenink 1992–2006). Subjects were told to redo any sentence they felt did not come out right; only the final pronunciation was used. After they had read all the sentences they were asked if they had heard of any of the ‘strange’ words ever before, and then if any of the words reminded them of a real Norwegian word. They marked the novel words and sentences accordingly. The majority of younger speakers were given these instructions in Norwegian by a school teacher. The majority of adult speakers were given these instructions first by reading them in Norwegian and then conversing with me about them in English.

The test words are given below, broken into two groups: those that reflected the basic pattern and those that were subject to a minor pattern of stress. While most are not real Norwegian words a few were included that were found in a Norwegian dictionary but most speakers are unfamiliar with. Such words are marked by an asterisk.

1The words are grouped according to how they were stressed, and so only the groups that proved to be independently interesting are given. Three pairs of similar words (makun/mokin, kitaba/katiba, santeku/sentaku) were included to see if there was any difference in the tendency to stress a back versus a front vowel. It was found that there was not (p=0.14, 0.39, 0.42, respectively) and so both versions are included in the appropriate shape category in (3). The four vowel-initial words in the consonant-final category (bottom of first column) were examined as a separate group to see if penultimate stress was more likely for consonant final words that were vowel-initial, but it was found that it was not (p=0.4) (compared to the words at the bottom of the second column which are identical except for the presence of an initial onset). Thus they are grouped in the consonant-final category. Additionally, each of six consonant-final words in the third column were also included in a second sentence in which they played the role of a proper name. It was found, however, that there was no difference (p=0.19) in the stress between these and their common noun counterparts and so these words are included here only as common nouns.
(3) Words reflecting the basic pattern

<table>
<thead>
<tr>
<th>shape</th>
<th>word</th>
<th>word</th>
<th>word</th>
</tr>
</thead>
<tbody>
<tr>
<td>C final$^2$</td>
<td>tirut</td>
<td>kavarapt</td>
<td>mokin</td>
</tr>
<tr>
<td>(non</td>
<td>luman</td>
<td>ronbun</td>
<td>dabal</td>
</tr>
<tr>
<td>exceptional</td>
<td>paragon*</td>
<td>gusord</td>
<td>dartun</td>
</tr>
<tr>
<td>Cs</td>
<td>palkut</td>
<td>ablativ*</td>
<td>tetofok</td>
</tr>
<tr>
<td></td>
<td>tulgan</td>
<td>akrostikon*</td>
<td>emelhat</td>
</tr>
<tr>
<td></td>
<td>agat*</td>
<td>dagat</td>
<td>folnamut</td>
</tr>
<tr>
<td></td>
<td>arak*</td>
<td>tarak</td>
<td></td>
</tr>
<tr>
<td></td>
<td>orlon*</td>
<td>porlon</td>
<td></td>
</tr>
<tr>
<td></td>
<td>akun</td>
<td>makun</td>
<td></td>
</tr>
<tr>
<td>V final</td>
<td>kitaba</td>
<td>heavy ante</td>
<td>santeku</td>
</tr>
<tr>
<td>(light</td>
<td>katiba</td>
<td>(CVC.CV.CV)</td>
<td>sentaku</td>
</tr>
<tr>
<td>ante)</td>
<td>fekulu</td>
<td></td>
<td>burkolus</td>
</tr>
<tr>
<td></td>
<td>sudoma</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>bumi</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>honko</td>
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</tr>
<tr>
<td></td>
<td>suranto</td>
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</tr>
<tr>
<td></td>
<td>eoto</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iepa</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>devanagari*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^2$There are so many words in this category in part because an effort was made to include various shapes within each category and consonant-final words have more possible shapes, than, for example, vowel-final words with final hiatus, which are limited to one shape. Further, some words were thought to be members of a minor pattern (vowel-initial words) but proved not to be, enlarging the category further.
(4) Words reflecting minor patterns

<table>
<thead>
<tr>
<th>[s] final</th>
<th>karsis</th>
<th>[ks] final</th>
<th>kuliraks</th>
</tr>
</thead>
<tbody>
<tr>
<td>pasas</td>
<td>akoltas</td>
<td>pefutiks</td>
<td>genroks</td>
</tr>
<tr>
<td>adipositas*</td>
<td></td>
<td>dikuks</td>
<td></td>
</tr>
<tr>
<td>final hiatus</td>
<td></td>
<td>dapie</td>
<td></td>
</tr>
<tr>
<td>vedrio</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>[eC]-final</th>
<th>mojultet</th>
<th>tamiser</th>
<th>kedumer</th>
<th>haroset*</th>
<th>lafem</th>
<th>sovedek*</th>
</tr>
</thead>
</table>

The novel words were put into sentences in which they played the role of a common noun with masculine gender (although three sentence frames instead cast them as either a mass noun or a singular neuter noun). The sentence frames used are given in (5). The real but unknown words were not randomized for carrier frames but instead given their own, listed in (6), so that they appeared in semantically plausible, yet generic, sentences.

(5) Test sentences for common nouns

a. Det var en ___ på stranda
   there was a ___ on beach-the

3The novel word sovedek was not included in the final data set because it contained the recognizable word sove (‘sleep’) and so was often treated like a compound word by subjects. Many subjects flagged it as close to a real word.
b. Han observerte en ___
   he watched a ___

c. De hvisket om en ___
   they whispered about a ___

d. De kjøpte en ___ på butikken
   they bought a ___ at store-the

e. En ___ løp inn i buskene
   a ___ ran in bushes-the

f. Barna så en ___
   children-the saw a ___

g. Han hadde en ___ i tankene
   he had a ___ on his-mind

h. De kuttet noe ___
   they cut some ___

i. En ___ var interessant
   a ___ was interesting

j. De kastet ut en ___
   they threw out a ___

k. Barna ble skremt av en ___
   children-the got scared by a ___

l. De så en ___ i sjøen
   they saw a ___ in sea-the

m. Det var en ___ å se
   there was a ___ to see

n. Han ble bitt av en ___
   he got bit by a ___

o. Det var ungene som fant en ___
   it was children-the who found a ___

p. De så ut som en ___
   it looked like a ___
q. Guttene hadde med seg en ___ 
boys-the had with them a ___

r. Han hoppet over en ___
  he jumped over a ___

s. Han la en ___ på bakken
  he put a ___ on hill-the

 t. Han knakk en ___ i to
   he broke a ___ in two

u. Det krøp en ___ forbi
   there crept a ___ past

v. De snakket om en ___
   they talked about a ___

w. Det var en ___ som forsvant
   it was a ___ that disappeared

x. De hadde en ___ å forholde seg til
   they had a ___ to keep-in-mind

y. Han la en ___ i boksen
  he put a ___ in box-the

z. Det var en ___ i huset
   there was a ___ in house-the

aa. Han plukket opp en ___
  he picked up a ___

bb. Hun arbeidet med en ___
  she worked with a ___

cc. De ble en ___ som kom
   it was a ___ that came

dd. Han ramlet på en ___
   he fell on a ___

ee. En ___ ble fanget
   a ___ was found
ff. Han så en ____ i skogen
   he saw a ____ in forest-the

gg. Vi så en grønn ____ i huset
   we saw a green ____ in house-the

hh. Jeg tråkket på en ____
   I fell on a ____

ii. På kjøkkenet stod det en ____
    in kitchen-the stood there a ____

jj. Han så på en ____
    he looked at a ____

kk. De ventet på en ____
    they waited for a ____

ll. De vandret gjennom en ____
    they strolled through a ____

mm. Han fikk med en ____ på kjøpet
    he got (it) with a ____ “for free”

nn. De bærte en ____ hjem
    they carried a ____ home

oo. Det lå en ____ i buskene
    there lay a ____ in bushes-the

pp. De helte oppi noe ____
    they poured in some ____
   “They poured ____ into something”

qq De kjøpte litt ____
     they bought [a] little ____

rr Barnet sprakk en ____
    child-the popped a ____

(6) Test sentences for real but unknown words

a. Produktet var laget av ablativ
   product-the was made of (a kind of) plastic
b. Han leste et akrostikon
   he read an acrosticon [name poem]

c. Han brukte en paragon
   he used a (pad of) receipts

d. Han lærte om devanagari
   he learned about devanagari [Indian alphabet]

e. Det var problemer med adipositas
   there were problems with obesity

f. De laget litt haroset
   they made (a) little charoset [a Passover food]

g. De bærte noe orlon hjem
   they carried some orlon [acrylic fiber] home

h. De drakk arak
   they drank arrack [Asian beverage]

i. De beundret noe agat
   they admired some agate [colorful quartz]

Together with a a native Norwegian speaker I subsequently listened to the recordings and marked the test sheets for novel word stress. We listened to the pronunciations together and came to an agreed-upon decision of the stress placement. Words that were pronounced incorrectly were discounted. Words were considered to be pronounced incorrectly if sounds were omitted, or added, or different phonemes were pronounced from the ones indicated by the spelling. Two speakers were entirely discounted due to almost consistent mispronunciations, leaving the results from 37 subjects. In the following three sections I examine the results of this experiment.
4.2.2.1 Statistical significance

A loglinear model was fitted to assess the differences in word shape. Because two syllable words were modeled with longer words, the dependent variable, ‘stress’, was alternatively coded to have only two levels: non-final stress and final stress, which I will refer to as the ‘binary stress model’. Thus, antepenultimate and penultimate stress were merged. A loglinear model with only words of at least three syllables was also fitted, with three levels of stress, in order to examine the distribution of antepenultimate stress in shapes where it is predicted.

One level of each factor is taken as part of the reference category by the model. The effect of different factors, such as word shape, is then judged by whether that factor significantly affects the odds of a particular stress (e.g. the odds of final stress), as compared to the reference category. Therefore there are several versions of the binary stress model, with varying reference categories.

The factors considered were word shape and subject age. Subjects were categorized into one of two age groups, the younger comprising 24 subjects ranging in age from 12 to 15, with a median age of 12, the older group comprising 13 subjects, ranging in age from 16 to 29, with a median age of 25. I will refer to the two groups as ‘younger speakers’ and ‘adult speakers’.

4.3 Analysis of basic stress pattern

An optimality theorectic analysis of the basic stress pattern of Norwegian is proposed, drawing on the lexicon and the results of the novel word experiment. I first show how the correct distribution of long vowels and geminates in Norwegian is
assured. I then show that stress is final whenever the final syllable can surface as heavy. I then examine cases of non-final stress, which arise when the final syllable cannot surface as heavy, and show that when stress is non-final the language shows quantity sensitivity. Finally, I give a ranking of all the relevant constraints.

4.3.1 Length in OT

As discussed in §1.4, long vowels and geminates only occur in stressed syllables. It is assumed that vowels in syllables that would otherwise surface as light and stressed are subject to vowel lengthening. In chapter three it was argued that length is the primary characteristic of long vowels and geminates (rather than a consequence of weight). It was proposed that length is encoded in root nodes. It is a standard assumption that the presence of a root node introduces a singleton segment. A sequence of two adjacent, identical root nodes that dominate all the same features (shared or not) will be realized as a long segment. Assuming this representation, I show how length in Norwegian can be correctly predicted in an OT analysis.

Long vowels and geminates have in common that they involve two identical root nodes with all the same features, as illustrated in (7). The alphabetic constants stand in for all features below the root node. Identical alphabetic constants within one example indicate that all features are the same.

(7) a. Long vowel  
   b. Geminate

\[
\begin{array}{cc}
[V] & [V] \\
A & A \\
\end{array}
\quad \begin{array}{cc}
[C] & [C] \\
B & B \\
\end{array}
\]
The OCP (Goldsmith 1976, McCarthy 1986) will presumably force all identical features of such identical, adjacent root nodes to be shared.4

(8) OCP: No identical, adjacent autosegments

(9)  
\( \begin{align*} 
\text{a. Long vowel} & \quad \text{b. Geminate} \\
[V] & \quad [V] \\
\rightarrow A & \quad \rightarrow B \\
[C] & \quad [C] 
\end{align*} \)

However, whether or not all the features are shared, a long vowel or geminate is assumed to occur in the case that there are two identical, adjacent root nodes that have all the same features.

Long vowels and geminates are both marked and I assume this is due to their phonological duration; that it is marked for an articulation to be phonologically prolonged. We may assume a general markedness constraint which states that segments may not be long.

(10) \*Long: The sequence of two identical, adjacent root nodes that have all the same features is prohibited (“segments may not be phonologically long”)

Long vowels and geminates are licensed only if one of their root nodes is part of the rime of a stressed syllable. Thus, a geminate is licensed if and only if it is dominated by the rime node of a stressed syllable. It may also be dominated by

---

4Identical root node features will of course not be shared, as having separate root nodes is needed to maintain the number of segments. We do not want root node features to be subject to the OCP because this would predict that a language with the ranking OCP \( \gg \) MAX would prefer to delete a segment rather than violate the OCP, an implausible preference.
an onset node, but this by itself is not sufficient. This can be seen as a kind of “safe prosodic path” as proposed by Ito and Mester (1993).

(11) a. Safe prosodic path for length

```
  Wd
    \sigma
    \sigma
    O \ R \ O \ R
    C \ V \ C \ C \ C \ V \ C \ V
```

b. Unsafe prosodic path for length

```
  Wd
    \sigma
    \sigma
    O \ R \ O \ R
    C \ V \ C \ C \ V \ C \ C \ B \ C \ D
```

The geminate in the first templatic word is licensed because there is a path from the geminate to the rime of the stressed syllable. However, this is not the case for the geminate in the second templatic word: no part of it is dominated by the rime of the stressed syllable. The positional licensing requirement that allows long vowels and geminates to surface only in stressed syllables is STRESS-TO-WEIGHT.

(12) STRESS-TO-WEIGHT: A syllable bearing primary stress must be heavy.

Since underlying long vowels and geminates may only surface in syllables bearing primary stress, we know that STRESS-TO-WEIGHT outranks *LONG. Otherwise, however, the prohibition against long vowels and geminates is enforced, meaning that *LONG outranks MAX, the constraint that prohibits deletion.

(13) MAX: A segment in the input must be present in the output

The tableau in (14) shows how a templatic word with two underlying geminates surfaces. Again, “C” and “V” represent root nodes and identical features are represented collectively by alphabetic constants. The rankings of ONSET and OCP are not determinable as candidates that violate them are harmonically bounded.
<table>
<thead>
<tr>
<th></th>
<th>Onset</th>
<th>OCP</th>
<th>StW</th>
<th>*LONG</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>σ_μ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O R O R</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C V C V C C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A B</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b.</td>
<td>σ_μμ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O R O R</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C V C V C C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**!</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>σ_μ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O R O R</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C V C V C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td>**</td>
</tr>
<tr>
<td>d.</td>
<td>σ_μμ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O R O R</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C V C V C C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>σ_μ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>O R O R</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C V C V C C</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A B B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>
The preservation of geminates in stressed syllables only may be seen from the comparison of candidate (a) to candidate (b). This comparison shows the crucial ranking of *LONG above MAX. One violation of *LONG is necessary, as can be seen from the comparison of candidate (a) to candidate (c). Thus the ranking STRESS-TO-WEIGHT ≫ *LONG ≫ MAX restricts geminates to stressed syllables. This ranking also predicts the preservation of underlying long vowels only when they have a path to the rime of a stressed syllable.5

If a light syllable would otherwise surface as stressed it is assumed that the vowel lengthens so as to satisfy the requirement that stressed syllables be heavy (as discussed in §1.4.2 and §3.2). The fact that the vowel will lengthen to satisfy STRESS-TO-WEIGHT tells us that the faithfulness constraint DepV, which penalizes epenthetic vowels, must be lowly ranked. Since we see vocalic root nodes being inserted but not consonantal root nodes, DepC must be undominated.

(15) a. DepV: A vowel may not be inserted
   b. DepC: A consonant may not be inserted

The tableau in (16) shows how the ranking DepC ≫ DepV, in conjunction with the ranking STRESS-TO-WEIGHT ≫ *LONG established in (14), causes the predicted type of syllable augmentation under stress. The full syllable structure is not shown. For simplicity I will indicate a syllable’s mora count as a subscript on the right edge of the syllable.

5The current analysis wrongly predicts that a stressed syllable that had an underlying long vowel and geminate (/CVːCː/) would surface faithfully. I assume there are higher-ranked syllable size constraints which would rule this out.
As can be seen, some violation of Dep is required in order to satisfy the un
ominated constraint Stress-to-Weight that requires that a stressed syllable be heavy. Candidate (b) again shows that phonologically long segments are lim-
ited to the rime of stressed syllables. Candidate (c) does not epenthesize a root node and so it fails on Stress-to-Weight. Candidate (d) shows that vowels, not consonants, in an otherwise light syllable are forced to lengthen under stress. Because the constraint that disallows epenthesi
 of a consonantal root node is un-
ominated, a candidate that satisfies the weight requirement through gemination is non-optimal.

I now turn to the placement of stress in Norwegian. I will henceforth only con-
sider candidates that respect that vowels, not consonants, lengthen where required and that length is confined to stressed syllables.
4.3.2 The primacy of final stress

Assuming the analysis of length in the previous section, I lay out each piece of the basic stress pattern in Norwegian, motivated by evidence from the lexicon and the novel word experiment, and then show how these predictions for stress placement can be captured in an OT analysis.

The basic stress algorithm is given in (17) (repeated from (28) in chapter one).

(17) a. If the word ends in a consonant, stress the final syllable
    b. Otherwise, stress the penult
    c. unless the penult is light and the antepenult is heavy, in which case, stress the antepenult

We expect words that end in a consonant to receive final stress, as shown by the examples in (18).

(18) Examples of underlying shapes that result in final stress

<table>
<thead>
<tr>
<th>/...CVCC/#</th>
<th>gloss</th>
<th>/...CVC/#</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>elefánt</td>
<td>‘elephant’</td>
<td>tulipán</td>
<td>‘tulip’</td>
</tr>
<tr>
<td>horisónt</td>
<td>‘horizon’</td>
<td>basár</td>
<td>‘raffle’</td>
</tr>
<tr>
<td>alárm</td>
<td>‘alarm’</td>
<td>basú:n</td>
<td>‘basoon’</td>
</tr>
<tr>
<td>almanákk</td>
<td>‘almanac’</td>
<td>sjakál</td>
<td>‘jackal’</td>
</tr>
<tr>
<td>klarinétt</td>
<td>‘clarinet’</td>
<td>tomá:t</td>
<td>‘tomato’</td>
</tr>
<tr>
<td>bagatéll</td>
<td>‘trifle’</td>
<td>dipló:m</td>
<td>‘diploma’</td>
</tr>
</tbody>
</table>

This was supported by the results of the novel word experiment, as shown in (19). A bar graph is shown for words of three of more syllables and for two-
syllable words. There were more two syllable words in the data set and so it is the distribution of each, rather than the raw counts, which should be considered.

(19) Stresses on C-final words

Looking at the bar graphs, it is clear that final stress is the most common response. A binary stress model found that consonant-final words are significantly more likely to have final stress \((p<0.0001)\) than vowel-final words, supporting the description in (17). It can also be seen that there were a large number of two syllable words where stress was put on the penult. However, when we break this response down by age range, it becomes evident this is largely due to the responses of the adult speakers.
Stresses on words that end in a consonant by age range

(a) 3 (or more) syllable words

(b) 2 syllable words
There were more subjects in the younger age range (24 subjects) than in the adult group (13 subjects). Therefore it is again the distribution of the pronounced stresses, rather than the raw counts of each stress, that should be compared between the two age groups. Younger speakers usually pronounced consonant-final words with final stress, as the proposed algorithm for stress in Norwegian predicts ($p<0.0001^6$). The adult speakers, however, pronounced more antepenultimate stress on words of three or more syllables and stressed the penult as often as the final syllable in words of two syllables. (While the raw number of antepenultimate stresses is not that much larger than the raw number for younger speakers, it represents proportionally more instances ($\sim32\%$ verses $\sim12\%$) of antepenultimate stress because there were fewer adult speakers among the subjects).

I suggest that this difference in age is not due so much to age as to experience with English. Disyllabic English nouns are likely to have penultimate stress (as compared to verbs, which are more likely to have final stress (Chomsky & Halle 1968, Liberman & Prince 1977)). Multisyllabic English nouns often have stress on the antepenult (whereas three-syllable or longer verbs are more likely to have penultimate stress (Schane 1979)). Because many recent loans into Norwegian come from English it is possible that speakers who know English would try to preserve the presumed original stress of a loan word. This would be consistent with the greater number of penultimate stresses on disyllabic words and antepenultimate stresses on three-syllable words seen in the adult age group in (20).$^7$

---

$^6$The effect of the younger age group on the likelihood of final stress within consonant-final words, taken from a binary stress model with consonant-final words as the reference shape.

$^7$Unfortunately the study did not include any measurement of subjects’ knowledge of English. However, it was clear from my interactions with subjects in administering the experiment that most subjects in the younger group were not fluent in English whereas most of the subjects in the adult group were extremely competent in English.
Thus, the younger speakers better reflect the basic stress pattern of Norwegian. The adult speakers also usually stressed the words according to the Norwegian pattern but were more likely than the younger speakers to place stress according to the English pattern, presumably because of their better knowledge of English.

The fact that stress appears word-finally when there is a final consonant means that stress is assigned as rightward as possible. Even if the final syllable is /CVC/, a shape that is not heavy on the surface, stress will still be final and CVC will be augmented to CV:C, a shape that is heavy word-finally (see §3.2). We therefore want the analysis to align the stress to the right edge of a word, as long as the final syllable is, or can be augmented to be, heavy. McCarthy (2003) argues that alignment constraints should not be evaluated gradiently, but rather, categorically. I employ his Rightmost-by-\(\sigma\) to capture this effect.

(21) **Rightmost-by-\(\sigma\):** No syllable intervenes between the main stress and the right edge of the prosodic word.

As the evaluation of this constraint is categorical, any non-final stress will cause it to be violated. So while it serves to place stress at the right edge if stress is non-final it does not cause it to be as near the right edge as possible.

Words that are underlyingly CVXC will have final stress. Final stress on such words will satisfy Rightmost-by-\(\sigma\) as well as Stress-to-Weight without augmentation. Therefore stress will always be final when the final syllable underlyingly has three segments in the rime.

Norwegian has been argued to be a moraic trochaic system (Rice 1999, 2006; Krisoffersen 2000; Lorentz 1996 uses syllabic trochees). However, there is very little evidence for feet in the language. If feet are assumed to be binary over moras,
then a stressed syllable is a foot by itself, as all stressed syllables are bimoraic. If
the head foot and head syllable always coincide then it is not possible to determine
the stress system to be either trochaic or iambic, since feet consist of a single
syllable. It is difficult, therefore, to find evidence for a particular foot type, or even
for the existence of feet in Norwegian at all. Further, the phonetic duration study
reported on in chapter two found that there was not significant lengthening under
secondary stress (where the words were coded as if they had alternating stress).
While this does not mean that there is no secondary stress (with other correlates)
it does contrast with a Dutch study (Rietveld, Kerkhoff and Gussenhoven 2004)
that found lengthening under secondary stress and concluded that the head of a
foot was subject to prosodic lengthening. The lack of lengthening gives a further
reason to be suspicious that feet may be absent from prosodic parsings. I formulate
an analysis that does not assume any footing, showing that all stress patterns can
be captured without reference to feet.

The example words are given in Norwegian spelling which is essentially trans-
parent. We know STRESS-TO-WEIGHT to be undominated, and that it outranks
DepV from (16). The ranking of RIGHTMOST-BY-σ has not been determined.
Syllables are marked in the candidates for weight. Weight is determined by ref-
ERENCE to (10) in §3.2.1, where a syllable shape that is, on average, at least 60%
greater than a CV syllable in the same position is categorized as heavy and as
otherwise is categorized as light. It was argued in §3.2.1 that a Norwegian speaker
knows the weight categorization of any given syllable shape in a given position
from experience with the language. There is no reason to think that a speaker
considers candidates that reflect the incorrect weight for a syllable. Therefore
the categorization of syllable weight, based on the proportional increase threshold
deduced in §3.2.1 is taken to be encoded as a constraint on Gen.

(22) Underlying final CVCC syllable (elefant ‘elephant’)

<table>
<thead>
<tr>
<th>/elefant/</th>
<th>Stress</th>
<th>Rightmost</th>
<th>DepV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TO-Weight</td>
<td>BY-σ</td>
<td></td>
</tr>
<tr>
<td>a. e₁le₂μf₂ánt₂μμ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. e₁le₂μf₂ánt₂μμ</td>
<td></td>
<td></td>
<td>*!</td>
</tr>
<tr>
<td>c. e₁lé₁μfant₁μμ</td>
<td>*!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d. e₁lé₁μfant₁μμ</td>
<td></td>
<td>*!</td>
<td>*</td>
</tr>
</tbody>
</table>

Stressing the final syllable satisfies both undominated constraints, that the
stressed syllable be heavy and that stress be final. Further, because the final
syllable is underlyingly CVCC, no augmentation is needed and so a violation of
DepV is unnecessary, as shown by the comparison of candidate (a) with candidate
(b).

Stressing the final syllable, as in candidate (a) above, results in a violation of
*Lapse, which penalizes sequences of two unstressed syllables (Selkirk 1984).

(23) *Lapse: No sequence of two unstressed syllables

It may either be the case that *Lapse is violated in such a word or, alternatively,
we could assume secondary stress on one of the non-final syllables. Stressing the
penult will result in a sequence of two stressed syllables and thus violate *Clash
(Selkirk 1984).

(24) *Clash: No sequence of two stressed syllables.
So either *Lapse is violated or the antepenult receives secondary stress, thus satisfying *Lapse and avoiding a violation of *Clash. Without a constraint that penalizes secondary stress the analysis predicts that secondary stress will occur on the antepenult of a word like elefant since *Lapse is otherwise needlessly violated. I therefore assume this secondary stress, as shown in (25). Note that alternating stress is predicted without the presence of feet.

(25) Alternating stress (elefant ‘elephant’)

<table>
<thead>
<tr>
<th>/elefant/</th>
<th>Stress</th>
<th>RTMOST</th>
<th>*Lapse</th>
<th>*Clash</th>
<th>DepV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TO-Weight</td>
<td>by-σ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. eᵢleᵢfántᵢ</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. eᵢleᵢfántᵢ</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>c. eᵢleᵢfántᵢ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If the final syllable is underlingly CVC, stress will still be final, but the syllable will need to be augmented in order to meet the proportional increase weight criterion. Candidates such as CVᵢCVCᵢ are not generated since GEN references something like the table in (10) in chapter two (the categorization of syllable weight on the basis of whether or not they meet the proportional increase threshold). This is justified by the fact that a speaker of Norwegian knows from experience that a CVC in final position does not meet the proportional increase threshold and is therefore light, not heavy. The example in (26) shows that stress will still be final when the rightmost syllable is underlingly CVC. Alternating stress, forced by *Lapse and *Clash, as shown in (25), is assumed.
Augmented final stressed CVC (tulipan ‘tulip’)

The tableau in (26) shows a final CVC syllable being augmented to CV: C. Vowel lengthening is necessary in order to satisfy Stress-to-Weight since a final CVC is light. As was shown in §3.2, the rime/word percentage of a word final CVC is 27% greater than that of a CV in the same position, falling far short of the minimum 60% increase that is needed for a syllable to categorized as heavy. Therefore candidate (b) fails on Stress-to-Weight. We know that vowel augmentation is preferable to consonant augmentation, and this causes candidate (a) to be selected over candidate (c), which lengthens the final consonant. The final candidate fails because it does not stress the final syllable, thereby violating Rightmost-by-σ.

Given clause three of the basic stress pattern in (17) we know that Norwegian will prioritize stressing an unaugmented heavy syllable over a more rightward syllable under certain conditions. However, the ranking of Rightmost-by-σ and Weight-to-Stress, the constraint that prioritizes a heavy syllable for stress, has not been determined. Weight-to-Stress is usually formulated with reference to feet: that a heavy syllable must be the head of a foot. However, the same idea
can be captured in a foot-less analysis by stating that a heavy syllable must bear (some level of) stress.

(27) **Weight-to-Stress:** A heavy syllable must bear stress

Looking at the lexicon of Norwegian we see that words that are underlyingly CVC.CVC# tend to receive final stress (e.g. bensín (‘gas’), sjasmín (‘jasmine’), *barbár* (‘barbarian’)). The results of the novel word experiment were more mixed, although (younger) speakers were much more likely to stress the final syllable than the penult (p=0.002). (Only data from younger speakers was considered with respect to stress placement in /CVCCVC/ words since adult speakers as a group were as likely to stress the penult as the final syllable in disyllabic consonant-final words (as discussed in connection to (20)). It was suggested that this might be due to their greater knowledge of English and application of the English stress pattern.) Looking at the responses for individual novel words, it is clear that there are a couple of words that were more likely to get stressed on the penult but that the majority of tokens overwhelmingly received final stress, just like other consonant-final words.\(^8\) This means that having stress be at the right edge is valued more highly than avoiding **Weight-to-Stress** (and **DepV**) violations. This is shown in (28).

---

\(^8\)Considering all novel /CVCCVC/ words as compared to /...CVCVC/ words we find that penultimate stress is more likely when the penult is heavy (p=0.001). However, if we remove one token, *ronbun*, we find that the difference between the two groups falls substantially (p=0.09) and is no longer significant at the 0.01 level. If we remove one further token, *orlon*, there is no significant difference between the two groups (p=0.48).
The final syllable, if unaugmented, is not heavy and therefore stressing the heavy penult does not incur a violation of Weight-to-Stress or DepV. But because Rightmost-by-σ is higher ranked, stress will be final. Notice that any candidate that fails to stress an unaugmented heavy syllable in favor of an augmented one will violate DepV as well as Weight-to-Stress. This is because the requirement that stressed syllables be heavy is undominated, forcing a violation of DepV anytime the stressed syllable would otherwise surface as light. Thus, Rightmost-by-σ must also be ranked above DepV. Presumably, *Clash is ranked above Weight-to-Stress, preventing secondary stress from falling on the heavy penult, as shown in (29).

In words like sjasmin the penult surfaces faithfully but does not draw stress. If, however, the penult had a long vowel or a geminate underlyingly, we would still predict stress to be final due to the ranking in (29), but since long vowels and geminates are licensed only in stressed syllables the penult could not surface.
faithfully. This shows us that Rightmost-by-σ outranks Max, as placing stress at the right edge is more important than preserving a long vowel or geminate. While a double consonant in the spelling usually signals a geminate in the pronunciation there are quite a few cases in which it does not (e.g. appéll (‘appeal’), fossíl (‘fossil’), effékt (‘effect’)). These spellings are suggestive of underlying geminates that are not able to surface. Further, given richness of the base, geminates and long vowels may occur freely in the input. The example in (30) illustrates that a non-final geminate will not surface if the word is consonant-final.

\[(30)\] Stress is final even at the cost of violating Max (fossíl (‘fossil’))

<table>
<thead>
<tr>
<th></th>
<th>LICENSE</th>
<th>RTMOS</th>
<th>MAX</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>/fossíl/</td>
<td>LONG, σ</td>
<td>by-σ</td>
<td>Max</td>
<td>TO-STRESS</td>
</tr>
<tr>
<td>a.</td>
<td>fóμσíl</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>fósμσíl</td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c.</td>
<td>fósμσíl</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

Because Rightmost-by-σ is ranked above Weight-to-Stress we find final stress even when the final syllable is not the rightmost heavy syllable. (Although, in order to successfully surface as stressed it will have to be augmented to satisfy Stress-to-Weight, a constraint not shown here but ranked above Rightmost-by-σ.) Because a long vowel or geminate is only licensed in a stressed syllable (long segments are taken to be marked because of their distinguished extended duration) the preference for stressing the rightmost syllable has the consequence of necessitating the deletion of one of the root nodes of the long segment. It was shown in (14) in §4.3.1 that the remaining root node will surface in the position of an onset, not a coda. Thus the optimal output for /fossíl/ is candidate (a).
Candidate (b) places stress on the rightmost syllable but by not deleting one of the root nodes contributing to the geminate it fails on the licensing constraint. Candidate (c) licenses the geminate by placing stress on the penult. However, this candidate fails because stress is not at the right edge. While the winning candidate avoids a Weight-to-Stress violation because it deleted a consonant root node, the ranking $\text{MAX} \gg \text{Weight-to-Stress}$ ensures that deletion will not occur to avoid a Weight-to-Stress violation. Thus the coda of a heavy unstressed syllable will not be deleted unless it is part of a geminate. The same applies to vocalic root nodes: a root node that is part of an unstressed diphthong (a heavy shape) will not be deleted, but one that is part of a long vowel will, as the licensing constraint is undominated.

Thus the analysis correctly predicts that stress will be final when the word ends in a consonant, regardless of the weight of other syllables. The real reason behind this is proposed to be that stress is at the right edge whenever the final syllable is, or can be augmented to be, heavy. If the final syllable ends in vowel, on the other hand, the final syllable is necessarily light and therefore stress will be forced to fall on a non-final syllable.

### 4.3.3 Non-final stress

Vowel final words are predicted to receive penultimate stress, unless the penult is light and antepenult is heavy. Examples of vowel-final words with penultimate stress are given in (31).
(31) Examples of underlying shapes that result in penultimate stress

<table>
<thead>
<tr>
<th>/...CVC.CV/ gloss</th>
<th>/...CV.CV/ gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>mángo ‘mango’</td>
<td>láma ‘llama’</td>
</tr>
<tr>
<td>distánse ‘distance’</td>
<td>dráma ‘drama’</td>
</tr>
<tr>
<td>disíppel ‘disciple’</td>
<td>égo ‘ego’</td>
</tr>
<tr>
<td>brudúlje ‘ruckus’</td>
<td>gamá:sje⁹ ‘spats’</td>
</tr>
<tr>
<td>fiásko ‘fiasko’</td>
<td>épó:ke ‘era’</td>
</tr>
</tbody>
</table>

Responses for cases in which the antepenult was light are broken down in (32). As can be seen from the bar graphs, vowel final words received overwhelmingly penultimate stress, as predicted (p<0.0001¹⁰). While the likelihood of final stress is slightly higher among the younger speakers (p=0.01) all speakers overwhelmingly stressed the penult and so the age groups are combined in the bar graphs in (32).

⁹The penultimate syllable in this word is not closed: the spelling ‘sj’ represents the voiceless palatal fricative.

¹⁰The odds of non final stress on vowel-final words, taken from a binary stress model with vowel-final words as the reference shape.
I propose that stress is non-final in such cases because the final syllable has no way to surface as heavy. An unaugmented CV is necessarily light. Further, as was argued in §3.2.1, a difference in vowel length is not able to be perceived word-finally (unsurprisingly, as this is a position in which many languages with a phonemic vowel length contrast neutralize it). Thus, even increased vowel length in a final CV will not result in a perceptually different syllable shape. It is therefore incongruous to consider candidates with a final long vowel.\textsuperscript{11} The only possible way for a final underlying /CV/ to be heavy on the surface is if a final consonant

\textsuperscript{11}I leave such candidates unconsidered, in a reflection of possible options a Norwegian speaker might consider. An alternative would be to rule them out through a constraint such as FIN-\textsuperscript{SHORT} (Prieto-Vives 1994) that requires all final vowels be short. While this constraint has the effect of forcing final vowel length neutralization it does not address the perceptual basis for this neutralization (Myers & Hansen forthcoming).
is epenthesized and the vowel lengthened. However, as this does not occur we can assume the prohibition against epenthesized consonants (DepC) is undominated. (This is in accord with the analysis of underlying length in §4.3.1 that required DepC to be ranked highly.) The predicted penultimate stress is therefore derived when a word is vowel final, as shown in (33).

(33) Heavy penult, light final (mango ‘mango’)

<table>
<thead>
<tr>
<th>/mango/</th>
<th>Stress</th>
<th>Dep</th>
<th>Rtmost</th>
<th>Weight</th>
<th>DepV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>to-Weight</td>
<td>C</td>
<td>by-σ</td>
<td>to-Stress</td>
<td></td>
</tr>
<tr>
<td>a. mángó</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. mángó</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. mángó</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. mángó</td>
<td>*</td>
<td>*</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is now evident that Stress-to-Weight outranks Rightmost-by-σ since a stressed syllable must always be heavy, even at the cost of being non-final. The second candidate is ruled out because the stressed syllable is light. As discussed above, mangó: is not considered as Norwegian speakers do not perceive a vowel length difference in final position. Even if it were considered, however, it would still fail on Stress-to-Weight as there is clear evidence (as discussed in §3.2.1) that final stressed CV, when it occurs, is light. The final syllable in candidate (c) is of a shape that is heavy in final position and therefore can bear stress but this comes at the cost of epenthesizing a final consonant which violated the undominated DepC. The fourth candidate shows that augmentation of the penult is unnecessary.
In (33), stressing the penult both satisfies Weight-to-Stress and incurs no violations of DepV. However, a vowel final word with an underlying /CV/ penult will also receive penultimate stress and the penult will be augmented so that Stress-to-Weight is satisfied, as shown in (34).

(34) Augmented penultimate stressed CV (lama ‘llama’)

<table>
<thead>
<tr>
<th></th>
<th>Stress-to-Weight</th>
<th>Dep</th>
<th>Rightmost by-σ</th>
<th>DepV</th>
</tr>
</thead>
<tbody>
<tr>
<td>/lama/</td>
<td>/láːmɑː/</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>a</td>
<td>lάːmɑː</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b</td>
<td>lamá</td>
<td>!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>lɑːmɑːt</td>
<td>!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>láːmɑː</td>
<td>!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Candidates (b) and (c) in (34) fail for the same reasons similar candidates failed in (33). There is no way for a final /CV/ syllable to surface as stressed without running afoul of Stress-to-Weight or DepC. Therefore the penult, augmented to satisfy Stress-to-Weight, is stressed.

In (33) and (34) there is only one syllable that can be augmented to satisfy Stress-to-Weight; however, we need to be able to predict the stress in longer vowel-final words as well. The basic pattern of Norwegian, as stated in (17), is that the penult will be stressed in vowel final words, unless the penult is light and the antepenult is heavy, in which case the antepenult will receive stress. The following tableaux show that if a word ends in a vowel, the penult will be stressed over the antepenult, unless the word is of the shape CVC.CV.CV.
(35) Heavy penult, light antepenult and final (brudulje ‘ruckus’)

<table>
<thead>
<tr>
<th>/brudulje/</th>
<th>Stress</th>
<th>Dep</th>
<th>Rtmost</th>
<th>Weight</th>
<th>Dep</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>to-Wt</td>
<td>C</td>
<td>by-σ</td>
<td>to-Stress</td>
<td>V</td>
</tr>
<tr>
<td>a. bruₘdúlₘjₑₘ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. bruₘdulₘjₑₘ</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. bruₘdulₘjₑₘₜₑₘ</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. brúₘₘdulₘjₑₘ</td>
<td>*</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

Candidates (b), (c) in (35) are ruled out for familiar reasons. The constraint ranking makes it impossible for a final /CV/ to surface stressed. Therefore either the penult or the antepenult will receive stress. Here candidate (a) wins because the penult does not require augmentation in order to meet the proportional increase threshold. If the antepenult is stressed instead, as in candidate (d), then either Weight-to-Stress or DepV is fatally violated.¹²

The penult is also stressed in vowel-final words in which both the antepenult and the penult are underlyingly /CV/, as was borne out by the results in (32). Stressing any non-final syllable will result in a single violation of Rightmost-by-σ, as seen for candidates (a) and (d) in (35). However, we can force the primary stress not to stray too far from the right edge though the constraint Rightmost-

¹²Languages that stress a heavy syllable over a light one are said to be quantity sensitive. Norwegian is quantity sensitive to a degree: it will stress the final syllable, when possible, at the cost of an unstressed heavy syllable elsewhere, but if final stress is not possible then weight considerations play a role. The behavior of quantity sensitive languages is generally assumed to be due to a relatively high ranking of the constraint Weight-to-Stress which requires that heavy syllables bear stress. However, as can be seen in the above tableaux, the effect of Weight-to-Stress is indistinguishable from the effect of DepV, since the language will require that the vowel of an otherwise light stressed syllable be augmented. (See the tableaux in (28) and (35).)
by-Stress, as formulated in (36). This constraint is based on McCarthy’s (2003) Rightmost-by-Foot, but does not refer to feet.

(36) Rightmost-by-Stress: No stressed syllable intervenes between the primary stress and the right edge of the prosodic word.

This will prevent the antepenult from being stressed and augmented in a /CVCVCV/ word, as shown in (37). Only candidates with non-final stress are shown, since final stress is known to be ruled out by the combination of undominated Stress-to-Weight and DepC.

(37) /CV.CV.CV/ (gamasje ‘spats’)

<table>
<thead>
<tr>
<th></th>
<th>Rightmost by-Stress</th>
<th>Stress to-Wt</th>
<th>*Lapse</th>
<th>Rightmost by-σ</th>
<th>Dep V</th>
</tr>
</thead>
<tbody>
<tr>
<td>/gamasje/</td>
<td>a. gaₜₚₜₚₜₜₛjeₜₚₜₜ</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>b. gaₜₚₜₚₛjeₜₚₜₜ</td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. gₜₚₚₜₜₜₜₛjeₜₚₜₜ</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>d. gₜₚₚₜₜₛjeₜₚₜₜ</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

All potentially viable candidates will violate Rightmost-by-σ, since, as we have seen, a final CV syllable cannot be stressed, and DepV, since all syllables were CV underlyingly and the stressed syllable will need to be augmented to satisfy Stress-to-Weight. The third and fourth candidates stress the antepenult. However, this either runs afoul of *Lapse, if no syllable bears secondary stress, or Rightmost-by-Stress, if the main stress is not the most rightward stress. Thus, Rightmost-by-Stress and *Lapse serve to keep the main stress toward
the right edge of the word. This can be seen in (38), showing this effect for an all-CV four syllable word.

(38) /CV.CV.CV.CV/ (anemone (‘anemone’))

<table>
<thead>
<tr>
<th>/anemone/</th>
<th>Rightmost by-Stress</th>
<th>Stress to-Wt</th>
<th>*Lapse</th>
<th>Rightmost by-σ</th>
<th>Dep V</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. àₘneₘmòₘneₘ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. aₘnéₘmoₘnéₘ</td>
<td>star</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. áₘnéₘmoₘnéₘ</td>
<td>star</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. aₘnéₘmoₘnéₘ</td>
<td></td>
<td>star</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. áₘnéₘmoₘnéₘ</td>
<td></td>
<td>star*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Here again, as in (22), we can assume that *Lapse forces secondary stress. The winning candidate in (37) did not include secondary stress because the penult bore the primary stress in a three-syllable word, meaning that a stress clash would result from a secondary stress. Stress cannot be final in (38) for known reasons: a final CV is always light. It cannot fall on the antepenult or pre-antepenult as this results in violations either of Rightmost-by-Stress (candidates (b) and (c)) or *Lapse (candidates (d) and (e)). Stress is therefore penultimate. The novel word experiment included one all-CV word longer than three syllables, devanagari. This is a real but largely unknown word that has exceptional stress in the lexicon (this is discussed further in §5.3.2) but usually received penultimate stress when pronounced by Norwegian speakers unfamiliar with the word. This, in conjunction with words in the lexicon such as anemone, sjokolade (‘chocolate’), and diorama (‘diorama’), supports the proposed analysis.
4.3.3.1 Quantity sensitivity in Norwegian

Words of the shape /CVC.CV.CV/ receive antepenultimate stress, as shown in (39). This is the situation in which the quantity sensitivity of the language surfaces as a heavy antepenult is stressed over a light penult.

(39) Heavy antepenult stressed over CV penult in vowel-final words

<table>
<thead>
<tr>
<th>word</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>índigo</td>
<td>‘indigo’</td>
</tr>
<tr>
<td>dóngeri</td>
<td>‘denim’</td>
</tr>
<tr>
<td>émbrýo</td>
<td>‘embryo’</td>
</tr>
<tr>
<td>kénguru</td>
<td>‘kangaroo’</td>
</tr>
<tr>
<td>ámfóra</td>
<td>[egg-shaped clay pot]</td>
</tr>
<tr>
<td>brókkoli</td>
<td>‘brokkoli’</td>
</tr>
<tr>
<td>kábbala</td>
<td>‘Kabbalah’ [oral Jewish philosophy]</td>
</tr>
</tbody>
</table>

The results of the novel word experiment supports this pattern, as shown in (40), although the tendency toward antepenultimate stress is not as overwhelming as one might expect.\(^\text{13}\)

\(^{13}\)The relatively large number of final stresses is particularly mysterious as there is no precedent for this in the lexicon and final stresses were rare in other vowel-final words (as shown in (32)). There is no significant effect of age for this shape (p=0.37) and so the two groups are shown combined.
Although there were a large number of non-antepenultimate stresses given to these words, there are strikingly more antepenultimate stresses in (40) than in the other graphs reflecting novel words of three or more syllables (in (20) and (32)). Within words of this shape, the likelihood of antepenultimate rather than penultimate stress is significant (p=.0005). (The likelihood of antepenultimate rather than final stress was also significant (p=0.003).)

We know that WEIGHT-TO-STRESS is ranked below RIGHTMOST-BY-σ (based on (28)), but if it is ranked above *LAPSE, then we can correctly predict antepenultimate stress, as shown in (41).
The constraint **Weight-to-Stress** selects candidate (a) over candidate (b). The ranking **Weight-to-Stress** ≫ *Lapse* is shown by this choice: it is preferable to stress a heavy syllable even at the cost of causing a *Lapse* violation. The *Lapse* violation cannot be avoided by placing a secondary stress to the right of the main stress because this would violate higher-ranked **Rightmost-by-Stress** as in candidate (c). (The same output would also be selected if DepV were ranked above *Lapse* rather than **Weight-to-Stress** but it will be shown later, in (44), that *Lapse* must dominate DepV.)

It is a consequence of this analysis of CVC.CV.CV words that we must assume there is no secondary stress to the right of an antepenultimate syllable bearing primary stress. As was noted in the discussion of words like *e.le.fánt* (‘elephant’), it is not known whether or not there is a secondary stress, which would be expected to fall on the antepenult in such words. It was assumed that we do find *éléfánt*, as secondary stress on the antepenult is predicted in order to avoid a gratuitous *Lapse* violation (see (25)), although the winning candidate could be altered if there were assumed to be a constraint that is violated by the presence of secondary stress ranked higher than *Lapse*. The absence of secondary stress is supported somewhat by the absence of significant lengthening found on syllables two syllables...
away from the primary stress in the production experiment reported on in chapter two. A further investigation of secondary stress is warranted as lengthening may not be its best perceptual correlate. Informal inquiry of a few native speakers found uncertainty as to whether or not there was secondary stress in three syllable words, but did find that secondary stress was perceived in four syllable words such as antilópe (‘antelope’), discussed later in the analysis.

We have seen that if the antepenult is heavy while the penult is light in a vowel-final word that stress is drawn to the heavy syllable. If the penult were also heavy, as in distánse (‘distance’), then the penult would be stressed over the antepenult in order to avoid a violation of *Lapse, as shown in (42). The constraint RIGHTMOST-BY-σ is not shown, as all potentially viable candidates violate it.

(42) CVC.CVC.CV (distánse ‘distance’)

<table>
<thead>
<tr>
<th>/distánse/</th>
<th>RIGHTMOST BY-STRESS</th>
<th>*CLASH</th>
<th>WEIGHT TO-STRESS</th>
<th>*LAPSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. dis_uτ𝑡μ’,tan_uτμ σ’μ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. dis_uττμ’,tan_uτμ σ’μ</td>
<td></td>
<td></td>
<td>!</td>
<td></td>
</tr>
<tr>
<td>c. dís_uττμ’,tan_uτμ σ’μ</td>
<td></td>
<td></td>
<td>*</td>
<td>!</td>
</tr>
<tr>
<td>d. dis_uττμ’,tan_uτμ σ’μ</td>
<td></td>
<td></td>
<td></td>
<td>!</td>
</tr>
</tbody>
</table>

Although the antepenult is heavy, main stress is penultimate because stressing the antepenult results in a *LAPSE violation. As we saw in (41), a *LAPSE violation is not fatal if it prevents a Weight-to-Stress violation. However, in this instance, where there are two adjacent heavy syllables, a Weight-to-Stress violation is inevitable, given that *CLASH is ranked above Weight-to-Stress.
The preceding tableaux have shown that we can expect penultimate stress when final stress is not possible. However, if the penult of a vowel-final word is light while the antepenult is heavy, then stress is antepenultimate. While all long vowels have thus far been the result of syllable augmentation, to make an otherwise light and stressed syllable heavy, there is evidence that there are some underlyingly long vowels in Norwegian. Specifically, these are vowels that were long in the source language, in this case, Latin. Words such as *aurora* (‘aurora’) and *albino* (‘albino’) receive penultimate stress. Discounting the long penultimate vowel, these words have the same shape as *indigo*, which was seen in (41) to receive antepenultimate stress. The fact that these words had a long vowel in the source language, however, provides an explanation for their penultimate stress. Norwegian speakers are conscious of vowel length. Even though long vowels only occur predictably (as seen so far), speakers presumably optimize their lexicon (Prince & Smolensky 1993) and so would store those long vowels underlyingly. Therefore we may assume that these words were loaned into the language with a long penultimate vowel. This gives them the same shape as *distanse* (‘distance’), shown in (42), and correctly predicts that they will receive penultimate stress, as illustrated in (43).
The first candidate is optimal for the same reason candidate (a) was in (42). The second candidate is harmonically bounded: it is not optimal because it both violates the terms of the licensing constraint for length by allowing the long vowel in the penult to surface unstressed, and it results in a *Lapse violation. Candidate (c) avoids a Weight-to-Stress violation by stressing both heavy syllables but this results in a fatal *Clash violation. The final candidate avoids a Weight-to-Stress violation by shortening the long vowel. This deletes a root node that was present in the input, however, and so violates Max, which we have already seen to be ranked above Weight-to-Stress. Thus, the long penultimate vowel is preserved under stress. I assume we may only plausibly rely on underlyingly long vowels to determine the stress when the vowel was long in the source language. We can therefore still predict where we find underlying long vowels: where needed for syllable augmentation, due to lexicon optimization, and where the vowel was long in the source language and is able to surface stressed in Norwegian.

The current ranking serves to place primary stress according to the basic stress algorithm previously stated. Stress is final if the word ends in a consonant because the final syllable will meet, or can be augmented to meet, the proportional increase.

<table>
<thead>
<tr>
<th>/alkoove/</th>
<th>Rtmost by-Stress</th>
<th>*Clash</th>
<th>Max</th>
<th>WT to-St</th>
<th>*Lapse</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. au₁₆₀₁₆₀₁₆₀₁₆₀ra₂₁₂₁</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. au₁₆₀₁₆₀₁₆₀₁₆₀ra₂₁₂₁</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. au₁₆₀₁₆₀₁₆₀₁₆₀ra₂₁₂₁</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| d. au₁₆₀₁₆₀₁₆₀₁₆₀ra₂₁₂₁ | | | | | *!

The first candidate is optimal for the same reason candidate (a) was in (42). The second candidate is harmonically bounded: it is not optimal because it both violates the terms of the licensing constraint for length by allowing the long vowel in the penult to surface unstressed, and it results in a *Lapse violation. Candidate (c) avoids a Weight-to-Stress violation by stressing both heavy syllables but this results in a fatal *Clash violation. The final candidate avoids a Weight-to-Stress violation by shortening the long vowel. This deletes a root node that was present in the input, however, and so violates Max, which we have already seen to be ranked above Weight-to-Stress. Thus, the long penultimate vowel is preserved under stress. I assume we may only plausibly rely on underlyingly long vowels to determine the stress when the vowel was long in the source language. We can therefore still predict where we find underlying long vowels: where needed for syllable augmentation, due to lexicon optimization, and where the vowel was long in the source language and is able to surface stressed in Norwegian.

The current ranking serves to place primary stress according to the basic stress algorithm previously stated. Stress is final if the word ends in a consonant because the final syllable will meet, or can be augmented to meet, the proportional increase.
threshold. The constraint \textsc{Rightmost-by-σ} forces final stress whenever this would not result in a violation of \textsc{Stress-to-Weight} or \textsc{DepC}. Stress is non-final if the word ends in a vowel since it is not possible to augment a final /CV/ to meet the proportional increase threshold without violating \textsc{DepC}. Stress is then drawn to the rightmost heavy syllable, within a three-syllable window. If the penult is heavy (regardless of the weight of the antepenult) it will receive stress because stressing a syllable further to the left would result in a violation either of \*\textsc{Lapse} or of \textsc{Rightmost-by-Stress}. If the penult is light and the antepenult is heavy then the antepenult will be stressed, avoiding violations of \textsc{Weight-to-Stress} and \textsc{DepV}. If both the antepenult and the penult are light, the penult will be augmented and stressed as augmenting and stressing the antepenult would result in an unnecessary violation of \*\textsc{Lapse}. The constraints \textsc{Rightmost-by-Stress} and \*\textsc{Lapse} prevent the main stress from falling further to the left than the antepenult. This is shown in (44) for a word with a heavy pre-antepenult which fails to draw the main stress.

(44) Heavy pre-antepenult fails to draw the main stress (\textit{antilope}, ‘antelope’)

<table>
<thead>
<tr>
<th></th>
<th>\textsc{Rtmt-by}</th>
<th>\textsc{Weight}</th>
<th>\textsc{Dep}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>\textsc{Stress}</td>
<td>\textsc{to-Stress}</td>
<td>\textsc{V}</td>
</tr>
<tr>
<td>/antilope/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. \textit{añt̂i̱l̂ó̱pe̱}</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. \textit{añt̂i̱l̂ó̱pe̱}</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>c. \textit{áñt̂i̱l̂ó̱pe̱}</td>
<td></td>
<td>!</td>
<td></td>
</tr>
<tr>
<td>d. \textit{áñt̂i̱l̂ó̱pe̱}</td>
<td></td>
<td>!</td>
<td>!!*</td>
</tr>
</tbody>
</table>

Main stress cannot fall on the pre-antepenultimate syllable, as in candidates (c) and (d), because this results in fatal violations of either \textsc{Rightmost-by-Stress}
or *Lapse. We can establish that *Lapse is ranked above DepV, since candidate (a) wins over candidate (d). When stress is non-final, the ranking Weight-to-Stress ≫ *Lapse forces a heavy syllable to be stressed. The constraint Rightmost-by-Stress keeps the main stress to a three-syllable window. If a heavy syllable occurs further to the left it will bear secondary stress, still satisfying Weight-to-Stress, while the penult bears the main stress. It is necessary that secondary stress on the heavy pre-antepenult satisfies Weight-to-Stress because otherwise we would predict candidate (d) as the winner. Speakers who were unsure of the presence of secondary stress in words like indigo were more confident that it was present in words like antilópe. Lorentz (1996) also reports secondary stress in longer words like antilope (but does not address the question of secondary stress in three-syllable words).

4.3.4 Proposed ranking

The ranking in (45) gives the overall ranking deduced to account for the basic pattern of stress in Norwegian. What constraints are dominated by OCP and Onset cannot be determined because, as we saw in (14), candidates that violate them are harmonically bounded. The OCP is therefore not shown in the Hasse diagram below. The constraint Onset can be deduced to be dominated by DepC since a consonant will not be epenthesized to satisfy Onset. (The ranking Weight-to-Stress ≫ *Lapse ≫ DepV is assumed as quantity sensitivity is usually captured by Weight-to-Stress.)
4.4 Comparison to alternative analyses and conclusion

The analysis proposed here differs from previous proposals for the Norwegian stress system in several ways, including in its treatment of the CVC weight asymmetry and the role of Weight-to-Stress.

The CVC weight asymmetry has been a particular sticking point for analyses of Norwegian because, as researchers note, it creates a paradox (Lorentz 1996, Kristoffersen 2000). If the final consonant is not part of the final syllable, then the final syllable is CV and not an appropriate landing site for stress. Therefore
the stress assignment algorithm needs to be sensitive to the presence or absence of the final consonant. A final CVC will then be an appropriate place for stress but it is a mystery why the vowel lengthens, since CVC is a heavy syllable. Therefore the final consonant needs to be seen in order to place the stress correctly but needs to be disregarded in order to correctly predict lengthening. This leads Kristoffersen (2000) to assume that final consonants are part of the final syllable and simply state that vowels in final stressed CVC syllables lengthen. Lorentz (1996) also concludes that stress assignment is necessarily sensitive to final consonants. Like the present analysis, he assumes that moras are not present underlyingly. While the analysis proposed here assigns moras to syllables, based on whether or not the syllable shape contrasts sufficiently with an unstressed CV syllable in the same position, Lorentz assumes moras are assigned to segments. In a heavy syllable this mora assignment will normally assign one mora to the vowel and one to the consonant. Word-finally, however, Lorentz proposes a VC rime has both moras assigned to the vowel, in order to preserve the contrast between V:C and VC:, where the latter will have one mora assigned to the vowel and one to the first consonant. (He assumes geminates are sequences of two identical consonants, as assumed here as well.) The analysis proposed here agrees with Lorentz on the basic point that the final consonant is crucially part of the final syllable. The proposed analysis differs in that rather than treating vowel lengthening in final closed syllables as contrast preservation, a reasonable analysis for Norwegian, it proposes that a final CVC, unlike a non-final CVC, is light because it does not sufficiently contrast with the duration of a final unstressed CV. This unites Norwegian with other languages that treat CVC as light word-finally.
Rice (2006) presents a thorough analysis of Norwegian stress couched in standard moraic theory. He assumes that word-final consonants are not part of the final syllable and that the final vowel lengthens in a /CVC/ syllable in order to satisfy STRESS-TO-WEIGHT, and so the final syllable is parsed as [CV:\.C]. Casting the CVC weight asymmetry in terms of NONFINALITY does away with the final-consonant paradox discussed above. However, it also requires thinking of a final consonant as separate from the final syllable which is a theoretical stipulation. The proposed solution motivates the CVC weight asymmetry through facts of perception and therefore gives a real explanation of the CVC weight asymmetry which is lacking in approaches that appeal to standard moraic theory (see §1.2.3 and §3.2).

There are also ways in which the proposed analysis of Norwegian stress differs from previous proposals. I give a comparison to two recent proposals for Norwegian stress (Kristoffersen 2000 and Rice 2006).

The grammar proposed here captures the following patterns (modified from (1)). Further minor patterns are analyzed in the following chapter.

(46) Basic stress pattern (Final CVC is light)

1. Consonant-final words receive final stress

2. Stress is otherwise penultimate

3. Unless the penult is light and the antepenult is heavy, in which case stress is antepenultimate
Pattern captured by Kristoffersen (2000) (Final CVC is heavy)

1. Consonant-final words receive final stress

2. Otherwise, the penult receives stress

3. Unless the word is lexically marked for final-syllable extrametricality, in which case the antepenult may receive stress if the penult is light

Kristoffersen’s analysis, as discussed at the beginning of this section, does not involve setting final consonants apart from the final syllable. This, along with the stipulation that vowels in final stressed CVC syllables lengthen resolves the final-consonant paradox. The analysis relies on right-aligned stress and a moraic trochaic foot which will foot a final CVC or will foot the final two syllables together if both or light. Given the trochaic stress pattern the penult in a (CV.CV) foot will be stressed.

Because the analysis is couched in pre-optimality theory terms an underlying CVCV sequence may be first grouped as a bimoraic foot and then the lengthening of vowels in open stressed syllables may be thought to apply later. However, the necessary vowel lengthening of the penult under stress upsets the foot form, as it will either need to be refooted or surface as a trimoraic foot. Thus a bimoraic foot only helps locate the position of stress if lengthening under stress occurs later in the derivation. As all surface heavy feet are a bimoraic foot to themselves, the role of footing does not play a distinct role in a non-derivational analysis such as the optimality theoretic analysis proposed here.

A bimoraic foot at the right edge of the word predicts final stress if the final syllable is CVC and penultimate stress otherwise. In order to get antepenultimate
stress Kristoffersen lexically marks some words for final syllable extrametricality. This has the effect of starting footing from the penult syllable. Therefore in such words the penult will be stressed if it is heavy, otherwise the antepenult will be stressed. This groups together words such as *índigo*, *fólie*, and *América* into an arbitrary class of words lexically marked for final-syllable extrametricality. In contrast, in the analysis proposed here, the first two words fall into classes that predictably get antepenultimate stress. The proposed ranking assigns antepenultimate stress to words of the shape CVC.CV.CV. Words of the shape CV.CV.V are part of a minor pattern identified and analyzed in the following chapter. Analyzing antepenultimate stress on words of the shape CVC.CV.CV and CV.CV.V as a regular pattern is supported by the results of the novel word experiment. Thus words such as *índigo* and *fólie* have predictable antepenultimate stress. Lexical marking is still needed for words such as *América* that have unpredictable stress, as will be discussed in §5.3.2. The analysis of *América* as exceptional is supported by the fact that words of the shape CV.CV.CV received overwhelmingly penultimate stress in the novel word experiment.

The analysis proposed by Rice (2006), as already noted above, makes use of **NonFinality** to explain the CVC weight asymmetry. It assumes bimoraic feet and this, along with the assumption that a foot boundary cannot divide a syllable, serves to limit non-final syllables to two rime segments and final syllables to three (as the final consonant is parsed outside the last syllable). Syllable size restrictions have not been discussed here but it assumed they may be otherwise limited, as onsets must be. (Although if this proves not to be the case, rime size restriction would be an argument for assuming feet are part of the prosodic structure of the
language, as long as we assume exhaustive footing.) The stress pattern captured by Rice’s analysis has a fundamentally difference from the analysis proposed here. While the proposed analysis predicts that stress will be at the right edge whenever possible (e.g. whenever the final syllable is heavy, or may be augmented to be heavy), the analysis in Rice 2006 predicts that the rightmost heavy syllable will be stressed.

(48) Pattern captured by Rice (2006) (Final CVC is light)

1. The rightmost syllable with a long vowel or geminate receives stress

2. Otherwise, if there is a final consonant, the final syllable is stressed

3. Otherwise the penult is stressed

This makes two different predictions from the grammar proposed here. One is that a heavy syllable left of the antepenultimate position will draw stress. This is falsified by words such as antilópe where a heavy pre-antepenultimate fails to draw primary stress. (Kristoffersen (2003) pointed out this problem with the analysis in Rice (2003).) In the proposed analysis, stress is limited to a three-syllable window by the ranking Rightmost-by-Stress $\gg$ Weight-to-Stress $\gg$ *Lapse, as this prevents primary stress from occurring further left than the penult except when the antepenult is heavy, in which case a *Lapse violation is sustained by the winning candidate in order to place primary stress on the heavy syllable. Primary stress cannot occur further to the left than antepenult as *Lapse violations may be avoided in longer words by placing primary stress on the penult and secondary stress on a heavy syllable further left than the antepenult, as was shown in (44). Thus the proposed analysis limits all regular stress to a three-syllable window.
The second way in which the stress algorithm in (48) differs from the analysis proposed here is that a non-final heavy syllable will pull the stress from a final CVC. This occurs because a final CVC is light and Weight-to-Stress is ranked above Rightmost. So, for example, penultimate stress is predicted on words of the shape /CVC.CVC/. It was argued in §4.3.2 that words of this shape receive final stress and so Rightmost-by-σ was ranked above Weight-to-Stress. This prediction is also made the analysis by Kristoffersen (2000) and stated by Lorentz (1996) and was found to be supported by the results of the novel word experiment. The analysis in (48) needs to assume underlying long vowels, for example, /sjasmín/, in order to correctly place final stress on such words.

The foundation of the analysis of Norwegian stress proposed here is the proposal for the categorization of syllable weight. The proposal put forward and motivated with the results from a phonetic experiment is that a final CVC is light because weight is based on a syllable’s contrast with the duration of an unstressed CV in the same position and a final CVC is not sufficiently distinct from a final CV. More raw length is needed word-finally in order for a syllable to be categorized as heavy because final lengthening at the word level causes increased rime duration. Thus, final heavy syllables are longer in order to maintain the same proportional increase that separates the duration of a non-final heavy syllable from a non-final CV, where proportional increase rather than raw increase is taken to be representative of perceptual distinction. This motivates the CVC weight asymmetry and predicts that we will find the same phonetically-based perceptual explanation in other languages with CVC weight asymmetry.
Chapter 5

Norwegian stress system
completed: Exceptions to the
basic pattern

5.1 Introduction

The previous chapter laid out an analysis that captures the basic stress pattern of Norwegian. I now turn to exceptions to the basic pattern, arguing that these should be divided into predictable exceptions, termed ‘minor patterns’ and true exceptions. The basic pattern and some exceptional patterns are given in (1) and (2), repeated from (1) and (2) in §4.2.1.

(1) Basic stress pattern

1. Consonant-final words receive final stress (e.g. elefánt, tulipá:n)

2. Stress is otherwise penultimate (e.g. mángo, lá:ma)
3. Unless the penult is light and the antepenult is heavy, in which case stress is antepenultimate (e.g. índigo, brókkoli)

(2) Exceptional patterns

- Penultimate stress on [s]-final words (e.g. aspárges, kókos)
- Penultimate stress on [Cs]-final words (e.g. bórraks, háubits)
- Penultimate stress on [er]-final words (e.g. kaníster, kalíber)
- Antepenultimate stress on V-final, final hiatus words (e.g. fólie, abrásio)
- Final stress on vowel-final French and Greek loan words (e.g. orkidé, kopí)

As previewed in §4.2.1, all but the final subgroup in (2) are minor stress patterns. What distinguishes these from the final subgroup in (2) is that words that follow one of these minor patterns are identifiable by their shape. It will be shown that the novel word experiment described in §4.2.2 supports the existence of minor patterns for all but the final subgroup. Minor patterns are analyzed in §5.2 while exceptions to regular stress patterns (basic or minor) are discussed in §5.3. A reflection on the effect of the identification of minor patterns is given in §5.4.

5.2 Minor patterns: identification and analysis

I look at each proposed minor pattern in turn, giving evidence from the lexicon and showing the relevant results of the novel word experiment. Language-specific ‘analogy’ constraints are proposed to capture these patterns. The proposal is that
speakers, on noting a subset of exceptionally-stressed words in their lexicon, will formulate an analogy constraint on the basis of that subset that will then apply to novel words as well.

5.2.1 Final [s]

Words that end in [s] usually receive penultimate, rather than final, stress. Examples of such words are given in (3).

(3) Penultimate stress on [s]-final words

<table>
<thead>
<tr>
<th>CVC.CV</th>
<th>gloss</th>
<th>CV.CV</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>amaríllis</td>
<td>‘amaríllis’</td>
<td>kókós</td>
<td>‘coconut’</td>
</tr>
<tr>
<td>aspárges</td>
<td>‘asperges’</td>
<td>adónis</td>
<td>‘adonis’</td>
</tr>
<tr>
<td>bámbus</td>
<td>‘bamboo’</td>
<td>básis</td>
<td>‘basis’</td>
</tr>
<tr>
<td>árktis</td>
<td>‘the arctic’</td>
<td>grá’tis</td>
<td>‘free’</td>
</tr>
<tr>
<td>Atlántis</td>
<td>‘Atlantis’</td>
<td>krókús</td>
<td>‘crocus’</td>
</tr>
<tr>
<td>átlash</td>
<td>‘atlas’</td>
<td>fó:kus</td>
<td>‘focus’</td>
</tr>
<tr>
<td>dískos</td>
<td>‘discus’</td>
<td>húrmus</td>
<td>‘dirt’</td>
</tr>
</tbody>
</table>

The novel word experiment found that words ending in [s] also tended to get penultimate stress. The bar graph in (4) compares the novel word stress of words ending in CV[s] to those ending in a different single consonant. There were more words in the data set that ended in a consonant other than [s] than there were words ending in [s], so again, what is relevant is the distribution of stress within each word shape, not the raw counts. It is evident that while words that ended in a consonant other than [s] usually received final stress, words that ended in [s] more
often received penultimate stress. Words that ended in [s] received penultimate stress significantly more often than other consonant-final words did (p<0.0001).

(4) Stresses on words that end in [s] versus another consonant

The above bar graphs show the overall responses for words of the relevant shapes. However, when we consider the stress put on CVs# words by younger Norwegian speakers (≤15 years old) separately from those of adult speakers (≥16 years old), a distinction emerges.
Here it is clear that while adult speakers tend stress the penult when a word ends in \[s\], younger speakers are evenly split between stressing the word according to the basic pattern of stress or following the minor pattern for words ending in \[s\]. Adult speakers were significantly more likely to stress the penult, as compared to the final syllable, than younger speakers were \((p<0.0001)\). It was shown earlier that adult speakers tend to stress a non-final syllable more often than younger speakers even when the final syllable is CVC. This was attributed to the greater knowledge of English of the adult speakers. However, it is clear that there is substantial difference between the stress adult speakers give to \([s]\)-final words: they are much more likely to receive penultimate stress \((p<0.0001)\). This comparison is shown in (6).
The fact that the younger speakers were split between following the basic pattern and following the minor pattern suggests that it is not anything phonetically different about [s]-final final syllables that make them unsuitable for stress, but rather exceptional stress on [s]-final words is a minor pattern that must be acquired by a speaker. The responses suggest that awareness of this minor pattern may be present during a speaker’s early teens although it may not be consistently employed. A possible mechanism that could fit this description is lexical analogy. Perhaps speakers become aware that most words in the lexicon that end in [s] do not have final stress and so by analogy do not assign final stress to novel words that end in [s]. If this kind of lexical cataloging and comparison often does not
occur until a later age it would explain why many younger speakers very often still assigned the basic stress pattern to novel [s]-final words.

Looking at individual speakers, it was not clear that a given speaker always followed the basic pattern, ignoring the minor pattern, or vice versa. However, there were only four words among the test words that ended in [s] and so it hard to tell if subjects who gave, for example, basic pattern stress to three of the [s]-final words and minor pattern stress to one were essentially following the basic pattern or were randomly assigning one stress pattern or the other.

One interesting question that emerges is whether speakers, are, by analogy, assigning penultimate stress to [s]-final words (comparable to the words in (3)) or if they are, by analogy, not assigning final stress (even though the words end in a consonant). If the analogy made is one that associates [s]-final words with penultimate stress then we should expect to see penultimate stress on [s]-final words (from speakers who have acquired the minor pattern) regardless of the shape of the word. On the other hand, if the analogy only prevents final stress, then we would expect to find antepenultimate stress on [s] final words with a heavy antepenult and light penult. One such word was included in the novel word test set, burkolus (grouped with the CVC.CV.CV words rather than with the [s]-final words in the analysis of the novel word experiment). It is difficult to draw firm conclusions from the limited number of data points but there is a striking contrast between the stresses placed on burkolus and those placed on folnamut, a word of the same shape except that its final consonant is not [s].
(7) Stress placed on **burkolus** by age range

(8) Stress placed on **folnamut** by age range
It is difficult to draw any conclusions from the responses of the adult speakers, especially since there are only 13 responses in this category for each word. However, the younger speakers show a strong pattern of responses. Most younger speakers assigned the basic stress pattern to *folnamut*, placing stress on the final syllable, while almost none stressed the antepenult. (It is not clear why there are a relatively large number of penultimate stresses.) A very different pattern emerges when looking at the stresses younger speakers placed on *burkolus*. The majority of younger speakers stressed the antepenult. There were also a fair number of final stresses, but only one speaker stressed the penult. Since we know (from the stresses placed on [s]-final words) that younger speakers have not all acquired the minor pattern associated with [s]-final words, we can assume the final stresses on *burkolus* result from the same lack of the minor pattern. However, whereas younger speakers who did not place final stress on [s]-final words placed it instead on the penult in (5), in (7) we see stress placed instead on the antepenult. This strongly suggests that the minor pattern is that [s]-final are exempt from final stress. This would mean that once, through analogy, the final syllable is ruled out, stress placement again reverts to the basic pattern. This will usually result in stress being placed on the penult, but in the case where the antepenult is heavy while the penult is light, it will result in stress being placed on the antepenult.

I propose a straight-forward analogy constraint to account for the non-final stress of [s]-final words. As discussed above, there is strong evidence that non-final stress on [s]-final words is not predestined due to any difference in the weight of [s]-final syllables in final position, but due instead is to speakers taking account of their lexicon and noting that [s]-final words behave differently from other
consonant-final words (presumably due to these words being loaned with their original stress).

(9)  

*C\'Vs# A final syllable closed with [s] does not receive stress

I propose that a constraint like *C\'Vs# is manufactured by the speaker and placed in the constraint hierarchy above RIGHTMOST-BY-\( \sigma \). Such a constraint makes a recurring idiosyncrasy in the lexicon into a minor pattern that will apply to novel words of the same shape.

Stress placement is shown for a consonant-final word, folnamut, which is subject to the basic stress pattern. Stress placement for two words that end in [s] is then shown, with the example words akoltas and burkolus. While both akoltas and burkolus are subject to the minor pattern for [s]-final words, the basic stress pattern treats them differently.

(10)  

Final stressed CVC (folnamut (novel test word))

<table>
<thead>
<tr>
<th></th>
<th>Stress</th>
<th>Rtmst</th>
<th>Weight</th>
<th>Dep</th>
</tr>
</thead>
<tbody>
<tr>
<td>/folnamut/</td>
<td>to-Wt</td>
<td>*C'Vs#</td>
<td>by-( \sigma )</td>
<td>to-Stress</td>
</tr>
<tr>
<td>a. f( \text{`o}l )( \mu ).n( \mu ).m( \text{`u}t )( \mu )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. f( \text{`o}l )( \mu ).n( \mu ).m( \text{`u}t )( \mu )</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. f( \text{`o}l )( \mu ).n( \text{`a} )( \mu ).m( \text{`u}t )( \mu )</td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d. f( \text{`o}l )( \mu ).n( \mu ).m( \text{`u}t )( \mu )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stress is (correctly) predicted to be final in folnamut because stress will be at the right edge where possible. In order to satisfy STRESS-TO-WEIGHT the final syllable must be augmented to a shape that meets the proportional increase threshold. Since DEPC (unshown) is highly ranked and DEPV is lowly ranked, the
final vowel will be lengthened to augment the syllable. The speaker-constructed
analogy constraint, *CVs#, is vacuously satisfied by all the candidates because
the final syllable does not end in [s]. The tableau in (10) models how a speaker
who is sensitive to the minor pattern concerning [s]-final words still places final
stress on words ending in other consonants. The analogy constraint plays a role
when the novel word ends in [s], as shown in (11) and (12) below.

(11) Final unstressed CVs, light antepenult (akoltas (novel test word))

<table>
<thead>
<tr>
<th>/akoltas/</th>
<th>Stress to-Wt</th>
<th>*CVs#</th>
<th>Rightmost by-σ</th>
<th>Weight to-Stress</th>
<th>*Lapse</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. åμ.<em>kolμ</em>.táςμμ.</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. aμ.<em>kólμ</em>.tasμ</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. áμμ.<em>kolμμ</em>.tasμμ</td>
<td></td>
<td>*</td>
<td>*!</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Although akoltas ends in a consonant and therefore we would be able to satisfy
Stress-to-Weight and Rightmost-by-σ (if the final vowel is lengthened),
the higher-ranked analogy constraint, *CVs#, prevents final stress. Stress will
therefore be either antepenultimate or penultimate. The particular word modeled
achieves two things by stressing the penult rather than the antepenult: it satisfies
Weight-to-Stress and it prevents a lapse from occurring. If the penult were
light it would still be stressed because stressing the antepenult (or any syllable
further to the left) would result in a lapse. However, if the penult is light and the
antepenult heavy, then we see the effect of Weight-to-Stress just as we did in
the basic stress pattern.
Stress on *burkolus* is determined both on the basis of analogy to [s]-final words in the Norwegian lexicon and on the basis of the basic stress pattern of the language. The analogy constraint prevents final stress and the constraint *Weight-to-Stress* causes the heavy antepenult to be stressed rather than the light penult.

I have argued that antepenultimate stress on a CVC.CV.CV.CVs word is due to non-final stress by analogy, and then the effect of *Weight-to-Stress*. Another possibility is that there is another analogy constraint that specifically places antepenultimate stress on words of this shape on analogy to such words in the Norwegian lexicon. Such words are very rare, however. I have been able to find only one, *ántabus*, which is a brandname of drug (‘antabuse’, used to treat alcoholism). This is not a word speakers would necessarily be aware of, especially younger speakers, who still usually placed antepenultimate stress on the novel word *burkolus*. We may assume that words of this shape are not common, and therefore would be unlikely to have as strong an effect on the stress of a novel word as is seen for *burkolus*. I therefore conclude the analogy constraint to [s]-final words in the lexicon prevents final stress, rather than specifically placing stress.
5.2.2 Final [s] clusters

Words that end in a [Cs] consonant cluster also tend receive penultimate stress.¹

(13) Penultimate stress on [Cs]-final words²

<table>
<thead>
<tr>
<th>CVks#</th>
<th>gloss</th>
<th>CVnks#</th>
<th>gloss</th>
<th>CVCs#</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>bó:raks</td>
<td>‘borax’</td>
<td>lá:rynks</td>
<td>‘larynx’</td>
<td>bíc:eps</td>
<td>‘biceps’</td>
</tr>
<tr>
<td>áp:eks</td>
<td>‘apex’</td>
<td>fá:rynks</td>
<td>‘pharynx’</td>
<td>há:ubits</td>
<td>‘howitzer’</td>
</tr>
<tr>
<td>app:éndiks</td>
<td>‘appendix’</td>
<td></td>
<td></td>
<td></td>
<td>[a short cannon]</td>
</tr>
<tr>
<td>fó:niks</td>
<td>‘phonics’</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pré:fi:ks</td>
<td>‘prefix’</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sú:fi:ks</td>
<td>‘suffix’</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>há:ripiks</td>
<td>‘sap’</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sý:ntaks</td>
<td>‘syntax’</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The distribution of stresses on novel [ks]-final words by age group is shown in (14). Again it is clear that younger speakers tend to apply the basic stress pattern to such words and that adult speakers are more likely to take the minor pattern into account.

¹Words with a final geminate [s] are exempt from this pattern: kompáss (‘compass’), kolóss (‘colasis’), albatróss (‘albatross’).
²But not on [sC]-final words: harnísk (‘armor’), basilísk (‘basilisk’ [legendary reptile; type of American lizard]).
Across ages, words that end in [ks] receive significantly more non-final stress than words that end in a final consonant (p=0.002), although they are more likely to be stressed according to the basic pattern than non-cluster [s]-final words (p=0.004). Adult speakers were much more likely to stress a non-final syllable in [ks]-final words than younger speakers (p<0.0001).

Again I propose that, rather than there being a phonotactic problem with stress falling on a syllable ending in a [s]-final cluster, novel words ending in such a consonant cluster get non-final stress by analogy to the words already present in the vocabulary of the language. This analysis explains why quite a few speakers still stress the final syllable, in accordance with the basic stress pattern of the language. It further offers a plausible explanation for the discrepancy between
the stress placement by younger versus adult speakers: younger speakers are less likely to be aware of (and/or make use of) the analogy to existing words.

The words in (13) seem to have been loaned into the language with their original stress intact. Notice that many of the words ending in a consonant cluster with a final [s] are lesser-known technical words, which offers an explanation for why fewer speakers stressed novel words according to this minor pattern than was seen for non-cluster [s]-final words. However, we can see from (14) that some younger speakers and many adult speakers do have knowledge of the minor pattern concerning [ks]-final words. Those speakers may be assumed to have a constraint that prevents final stress on [ks]-final words, constructed on the basis of such words in the Norwegian lexicon. I assume that this is a separate constraint than the analogy constraint proposed in the previous section, preventing non-cluster [s]-final words from receiving final stress, since we see a much stronger effect of the latter than the former among the same group of speakers. As shown in (13), [s]-final clusters other than [ks] also receive non-final stress. I did not include words ending in other [s]-final clusters in the novel word experiment so I do not know if they have the same analogical effect as [ks]-final words do. However, in the interests of generalizing until data forces us to treat them differently, I encode the analogy constraint for [ks]-final words to affect all [s]-final cluster words.

(15) *CVC(C)s# : A final syllable closed with an [s]-final cluster does not receive stress

I propose that speakers who are aware of the minor pattern affecting words with [s]-final clusters have formulated a constraint such as (15) and ranked it above Rightmost-by-σ.
Although no test words were of the shape CVC.CV.CVks, the proposed analysis predicts that such words would receive antepenultimate stress by those speakers who had acquired the minor pattern concerning words with [s]-final clusters.

### 5.2.3 Pseudo-polymorphemic words

Words ending in [er] often have penultimate stress, even though they end in a consonant and so would otherwise be predicted to receive final stress.

(17) Penultimate stress on [er]-final words

- "baluster’ [vase-shaped rail support]
- ‘railing’
- ‘calendar’
- ‘caliber’
- ‘candelabra’
- ‘canister’
- ‘catheter’/‘desk’

I propose that the [er]-final words tend to avoid final stress because [er] is the plural marker and so speakers may form an analogy to polymorphemic words,
where the plural does not draw stress. The novel word experiment included two [er]-final words, two [et]-final words and an [em]-final word. Words that ended in [et] were included because [et] marks the neuter definite and so monomorphemic [et]-final words would presumably fall victim to the same pseudo-polymorphemic analysis. There is no morpheme [em] in the language, however. There could be no actual confusion as all words were in a sentence frame in which they were preceded by the masculine indefinite article (or, in a few cases, by an indefinite quantifier for mass or neuter singular nouns), meaning the following noun could be neither plural nor neuter definite.

(18) Stresses on words that have an [e] in the final closed syllable

Words that ended in [er] received overwhelmingly penultimate stress, as suspected. The [et]-final words were more equally split between penultimate and final
stress, still showing more frequent penultimate stress than other consonant-final words. The [em]-final word, however, usually received final stress, as predicted by the basic stress pattern. While more [eC]-final words should be tested, I will assume that the tendency toward penultimate stress is due to the similarity of the ending to a separate morpheme rather than due to the presence of [e] itself and so will exclude stresses on Laem from consideration of this minor pattern.

The overall distribution of stress on consonant-final words with [e] in the final syllable is shown in (19) and can be compared to the stress on consonant-final words with other vowels in the final syllable, shown in (20). There was no significant different between age groups (p=0.47) and so both are represented in the bar graph in (19).

(19) Overall stresses on [er]/[et]-final words
I assume speakers avoid final stress in [er]-final and [et]-final words on analogy to the suffixes [er] and [et] which do not bear stress. We may capture this in the spirit of the analogy constraints proposed thus far, through the constraints *[ér]# and *[ét]#. I assume speakers formulate such constraints on the basis of the behavior of the morphemes [er] and [et] and generalize the pattern to monomorphemic words, as demonstrated in (22) for the novel word *tamiser*.

\[(21)\begin{align*}
\text{a. } & *[ér]# : \text{A final [er] does not bear stress} \\
\text{b. } & *[ét]# : \text{A final [et] does not bear stress}
\end{align*}\]
5.2.4 Final hiatus

Norwegian words that end in hiatus receive antepenultimate stress, as shown by the examples in (23).

(23) Antepenultimate stress on V-final, final hiatus words

<table>
<thead>
<tr>
<th>Word</th>
<th>Stress</th>
<th>Rtmost to-Wt</th>
<th>Rtmost by-Stress</th>
<th>Rtmost by-σ</th>
<th>*Lapse</th>
</tr>
</thead>
<tbody>
<tr>
<td>fólie</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>endí:vie</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>abrá:sio</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fú:rie</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>konký:lie</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Words with final hiatus were included in the novel word experiment. As can be seen from the bar graphs in (24) such words usually received penultimate, not antepenultimate stress. As there is no effect of age (p=0.1) the data from all speakers has been combined.

3But not on consonant-final words with final hiatus: bavián (‘baboon’), beduín, (‘bedouín/beduin’ [nomadic Arab tribe]).

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Since such words end in a vowel, the basic stress pattern of Norwegian predicts that they would receive penultimate stress and it appears that most speakers applied the basic stress pattern. Speakers tended to place penultimate stress rather than antepenultimate stress (p=0.02). However, final hiatus is included as a minor pattern because it is clear that there are more cases of antepenultimate stress in the case of final hiatus than with other vowel-final words (p<0.0001). This can be seen by comparing the distribution of stress in (24) to the graph for three-syllable vowel-final words (that did not have final hiatus) in (25).
(25) Stresses on three syllable, vowel-final words

Although not as strong as the minor pattern affecting [s]-final words, there is a minor pattern affecting words that end in hiatus. While the basic pattern predicts CV.CV.V receive penultimate stress, they are often stressed on the antepenult instead. Again this minor pattern does not seem to be due to any problem with penultimate stress under final hiatus within the grammar of Norwegian as in fact the penult is the most common syllable to be stressed in novel words with final hiatus, and so I assume that antepenultimate stress is the result of analogy to words of this shape in the lexicon of Norwegian. It is unexpected that this minor pattern is not applied more often, particularly by adult speakers. Perhaps there are relatively few words of this shape in the lexicon of Norwegian (to my knowledge this is the case) and so a speaker is less likely to form a minor pattern. There
were also only two such words in the novel word test set and so we have fewer
data points to judge from than we did when examining other minor patterns.

In the spirit of the previous analogy constraints proposed, the analogy con-
straint in (26) is formulated to prevent penultimate stress on words with final
hiatus rather than assign antepenultimate stress to such words.

(26) \(^{*}C\overline{\text{V}.V\#}\) No penultimate stress on words with final hiatus

It seems that stress cannot be on the first vowel in a heterosyllabic vowel sequence.
Consonant-final words with hiatus in the same position receive final stress, as
per the basic stress pattern (e.g. bavián (‘baboon’), beduín (‘bedouin/beduin’
[nomadic Arab tribe])). Further, words with initial hiatus (novel words eoto and
eipa) were included in the novel word test and they were stressed exactly like
other vowel-final words, on the penult, as can be seen in (27). This shows us that
stress is not avoided on the second vowel in a heterosyllabic vowel sequence.
Stresses on words with initial hiatus

Minor pattern stress placement for a word with final hiatus, *dapie*, is shown in (28).

(28) Final hiatus (*dapie* (novel test word))

<table>
<thead>
<tr>
<th></th>
<th>/dapie/</th>
<th>STRESS</th>
<th>RTMT-BY</th>
<th>RTMOST</th>
<th>*LAPSE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>to-Wt</td>
<td>*CV.V#</td>
<td>by-σ</td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>dâ´mu.piµ.êµ</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b</td>
<td>dâµ.piµ.êµ</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>dâµ.piµ.êµ</td>
<td></td>
<td>*!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>dµ.piµ.êµ</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

A speaker without the minor pattern concerning words that end in hiatus would not have the analogy constraint *CV.V#, and so would place penultimate
stress on such words, in accordance with the basic stress pattern. This is shown for comparison in (29).

(29) Final hiatus treated as regular V-final (dapie (novel test word))

<table>
<thead>
<tr>
<th>/dapie/</th>
<th>Stress to-Weight</th>
<th>Rightmost by-Stress</th>
<th>Rtmost by-σ</th>
<th>*Lapse</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. dâµπµ.µµ.êµ</td>
<td></td>
<td>*</td>
<td>*</td>
<td>!</td>
</tr>
<tr>
<td>b. dâµ.µµ.êµ</td>
<td></td>
<td></td>
<td>*</td>
<td>!</td>
</tr>
<tr>
<td>c. dâµµ.µµ.êµ</td>
<td></td>
<td></td>
<td>*</td>
<td>!</td>
</tr>
<tr>
<td>d. daµµ.µµ.êµ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.3 True exceptions: identification and analysis

In the previous sections, minor patterns that result in predictable exceptional stress were examined. I now turn to cases of exceptional stress that must be learned by lexical item. That is, there is no way to predict that the words will not follow the basic stress pattern.

5.3.1 Final stressed CV

Vowel-final loan words from French and Greek often violate the basic stress pattern of Norwegian by having final stress. Examples are given in (30). (Accents on final syllables are present in the spellings of some such words. Final stress is therefore not indicated as it would neutralize the accent marks.)
Unlike the minor patterns uncovered in Norwegian and shown in §5.2, words that have a stressed final CV syllable are not identifiable based on any characteristic shape. Rather, they are a united class because of their source. This is clearly a case where the stress in the original language is borrowed with the word. The test data set contained two and three syllable words that ended in a vowel. Vowel-final test words received overwhelmingly penultimate stress. The distribution of stress on vowel-final words is repeated in (31).
The fact that vowel final novel words were almost always stressed on the penult provides evidence that unlike, for example, [s]-final words in the grammar, the words like those in (30) do not cause novel words to deviate from the basic stress pattern.

The question then, is how such words are handled by the grammar. Since their final stress is not predictable by their shape, such words must be lexically marked in some way. I propose the words in (30) and those like them are lexically marked for final stress.

(32) \text{Faith-ProsodicHead}^4 \quad \text{A lexically marked prosodic head (primary stress) surfaces faithfully}
As was argued in §3.2.1, there is sufficient evidence to conclude that a final stressed CV is light even though it is stressed. First, if it is true that no vowel length difference is perceived word-finally then there is no way to phonologically distinguish a final unstressed CV from a final stressed CV. Second, we only find final stressed CV syllables in exceptional cases, such as in French and Greek loan words that preserve their original stress. If a final stressed CV were heavy we would expect to find final stress much more frequently as we have seen that stress occurs at the right edge whenever the final syllable can surface as heavy. The fact that we do not find final stress in CV-final words strongly suggests that CV is not heavy when stressed. Therefore I assume that the constraint in (32) is ranked above STRESS-TO-WEIGHT which has previously been thought to be undominated in the language. The constraint DEpC must also be ranked above STRESS-TO-WEIGHT since epenthesizing a final consonant (and lengthening the vowel) is the only way a final syllable can be augmented to satisfy STRESS-TO-WEIGHT.

(33) Exceptional final CV stress (kopi ‘copy’)

<table>
<thead>
<tr>
<th></th>
<th>Faith</th>
<th>Dep</th>
<th>Stress</th>
<th>Dep</th>
</tr>
</thead>
<tbody>
<tr>
<td>/kopí/</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. koμpipíμ</td>
<td></td>
<td></td>
<td>!*</td>
<td></td>
</tr>
<tr>
<td>b. koμpí:νμμ</td>
<td></td>
<td></td>
<td>!*</td>
<td></td>
</tr>
<tr>
<td>c. kó:νμμpiμ</td>
<td></td>
<td></td>
<td>!*</td>
<td></td>
</tr>
</tbody>
</table>

The constraint ranking proposed in chapter four forced stress to occur within a final three-syllable window. This constraint would allow a syllable to the left of the antepenult that was lexically marked for stress to surface faithfully. This is a reasonable result, however, because a speaker could always override the regular patterns and force stress to occur on, for example, the pre-antepenult, but such stresses are not part of any regular pattern.
The underlying main stress is preserved at the cost of violating the constraint requiring that a syllable bearing primary stress must be heavy.

### 5.3.2 Examples of other exceptions

There are other numerous unpredictable exceptions to the demonstrated patterns of stress. These include consonant-final words with penultimate or antepenultimate stress and vowel-final words with antepenultimate stress, including exceptions to the minor patterns. Some examples are shown in (34).

(34) Words with exceptional stress

<table>
<thead>
<tr>
<th>expect ( \dot{\sigma} # )</th>
<th>gloss</th>
<th>expect ( \dot{\sigma} \sigma # )</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>búson</td>
<td>‘bison’</td>
<td>dú:mino</td>
<td>‘domino’</td>
</tr>
<tr>
<td>ádvent</td>
<td>‘advent’</td>
<td>bas:flika</td>
<td>‘royal hall’</td>
</tr>
<tr>
<td>álbum</td>
<td>‘album’</td>
<td>apó:kope</td>
<td>‘apocope’</td>
</tr>
<tr>
<td>á:rak</td>
<td>[beverage]</td>
<td>ánima</td>
<td>‘soul’</td>
</tr>
<tr>
<td>fósfor</td>
<td>‘phosphor’</td>
<td>páprika</td>
<td>‘paprika’</td>
</tr>
<tr>
<td>kásjmir</td>
<td>‘cashmere’</td>
<td>ánanas</td>
<td>‘banana’</td>
</tr>
<tr>
<td>ekvá:tor</td>
<td>‘equator’</td>
<td>kalá:s</td>
<td>‘party’</td>
</tr>
<tr>
<td>dó:ktor</td>
<td>‘doctor’</td>
<td>harselá:s</td>
<td>‘mockery’</td>
</tr>
<tr>
<td>fénrik</td>
<td>[military rank]</td>
<td>kolláps</td>
<td>‘collapse’</td>
</tr>
<tr>
<td>fyllik</td>
<td>‘a drunk’</td>
<td>klavé:r</td>
<td>‘grand piano’</td>
</tr>
</tbody>
</table>

There were consonant-final words included in the experiment that are actual words in Norwegian, marked in the dictionary with non-final stress. These words were chosen to be included in the (mostly) novel word experiment because they are not familiar words to most Norwegian speakers. They therefore offer a window
into whether or not there is anything about their shape that forces exceptional stress (i.e. whether they are part of a minor pattern of some kind). If they have truly exceptional (non-predictable) stress speakers unfamiliar with the basic pattern should stress them according to the basic pattern. I show the distribution of stresses for three such words in (35).\footnote{The other two words were disyllabic, and their stress did not differ from that placed on disyllabic consonant-final novel words (p=0.23).} These words are all listed in the dictionary (Berulfsen & Gundersen 2003) with antepenultimate stress, although their shape seems to fall within the basic pattern, predicting final stress.
Stresses on real but unknown consonant final words

AGE = 15 or younger

AGE = 16 or older
The first bar graph in (35) shows that younger speakers did indeed assign the basic stress pattern to these words. Adult speakers assigned the basic stress pattern to *ablativ* overwhelmingly and to *paragon* usually but were split between antepenultimate and final stress for *akrostikon*. Leaving the adults’ stresses on *akrostikon* aside for the moment, we can conclude that there is nothing special about these words that predict unusual stress since speakers who did not know these words stressed them according to the basic pattern. We can therefore conclude that speakers who pronounce any of these words with antepenultimate stress must have learned this exceptional stress specifically, lexically marking the word for stress.

Subjects were asked after reading all the test sentences both whether they had ever heard any of the test words before and whether any of the test words reminded them of a real Norwegian word. Many subjects gave the Norwegian word *léksikon* (‘lexicon’) as being similar to the test word *akrostikon*. If some adult speakers stressed *akrostikon* on analogy to *leksikon*, that would explain why it received more antepenultimate stress than the other real but unknown test words. (*Leksikon* need not have lexical stress because there is also a word *léksika* that receives basic pattern stress and so *leksikon* is arguable not a simplex word.)

A real but unknown word that should receive penultimate stress is *devanagari*, which is listed in the dictionary as being stressed on the antepenult. It is evident that this must be lexically marked exceptional stress, however, as speakers who were not familiar with the word usually stressed the penult, in accordance with the basic pattern, as shown in (36).
The placement of stress on the real-but-unknown words included in the experiment show that these are cases of unpredictable, idiosyncratic stress. Speakers who did not know these words tended to stress them as though they followed the regular stress pattern in the language. Therefore we can assume that they, like the other words given in (34), have lexically marked stress. The undominated faithfulness constraint to an underlying prosodic head ensures that lexically marked stress will surface faithfully. We know from the previous section that it is ranked above \textsc{Weight-to-Stress} in order to allow final CV syllables lexically marked for stress to surface even though they are not heavy. In order to allow lexical stress to surface on words like \textit{páragon}, \textsc{Faith-ProsodicHead} must outrank \textsc{Rightmost-by-σ}.
If the constraint requiring faithfulness to an underlying prosodic head were not present, candidate (d), which reflects the regular Norwegian stress pattern, would win. However, this candidate is ruled out because it does not preserve the underlyingly marked stress. Notice that the ranking Faith-ProsodicHead ≫ Stress-to-Weight established in §5.3.1 does not predict that we will find light stressed syllables anywhere besides word-finally. Although it was seen that Stress-to-Weight was violated in kopí (in (33)) we see from the comparison of candidate (a) to candidate (b) in (37) that preservation of non-final lexically marked stress does not mean that the requirement of stressed syllables to be heavy is lifted.

It is assumed that a speaker only lexically lists stress if it is not predictable. It has been shown for some exceptionally-stressed words that their stress must be lexically listed, as speakers who are not familiar with a word will stress it according to the regular pattern. This supports the conclusion that stress must be lexically stored in such cases and differentiates them from words that are part of a regular stress pattern that is extended to novel words.
5.4 Conclusion

The analogy constraints proposed in this chapter capture the minor patterns stated in (38).

(38) Minor patterns

- Penultimate stress on [s]-final words
- Penultimate stress on [Cs]-final words
- Penultimate stress on [er]/[et]-final words
- Antepenultimate stress on V-final, final hiatus words

Exceptions to these regular stress patterns, the true exceptions (as opposed to the minor patterns, which are argued to be predictable exceptions), are assumed to have lexically marked stress, which undominated FAITH-PROSODICHEAD will preserve.

The proposal and support for minor stress patterns in the language largely does away with the need to assume underlying long vowels, which the analysis in Rice (2006) relies on, as discussed in §4.4. In Rice’s analysis, for example, words such *fókus, bórraks, and búnson are all taken to have underlyingly long penultimate vowels. And because, in his analysis, WEIGHT-TO-STRESS is ranked above RIGHTMOST, the long vowel pulls the stress to the penult. The analysis proposed here would normally predict final stress on these words but identifies the first two as being part of minor patterns that avoid final stress. This is again supported by the results of the novel word experiment which found that speakers
placed non-final stress on words that ended in [s] or [ks] significantly more often than on words that ended in other consonants. This makes the stress on words such as fokus and boraks independently predictable. The penultimate stress on bison is assumed to be unpredictable and therefore lexically marked, setting it apart from other words of that shape which are expected to receive final stress, as was usually the case in the novel word experiment. The only words that are assumed to have an underlying long vowel in the proposed analysis are those that are realized CVX.C\text{\`{e}}.CV, like auróra. The basic stress pattern would otherwise predict that such words receive antepenultimate stress. It was argued that these are words that had a long vowel in Latin, the language they were loaned from (cf. fokus, boraks, etc.) and that this long vowel was preserved, giving them the shape CVC.CVX.CV which is predicted to receive penultimate stress.

The analysis of Norwegian stress proposed and supported in this and the preceding chapter distinguishes predictable exceptions to the basic pattern from unpredictable exceptions. This was possible to do by looking to the results of the novel word experiment in which speakers usually applied the basic pattern but sometimes identified words as belonging to a minor pattern and stressed them accordingly. The constraint ranking proposed to capture the basic pattern, together with the proposed analogy constraints, gives a united analysis of regular stress in Norwegian. The undominated constraint \textsc{Faith-ProsodicHead} allows lexically-marked exceptions to the regular pattern to surface faithfully. This analysis captures the stresses in the lexicon of Norwegian and extends to novel words as well.
Chapter 6

Extrametricality revisited

6.1 Beyond Norwegian

I have shown how final consonant extrametricality may be reanalyzed if we consider the categorization of syllable weight to be based on maintaining a consistent minimum perceptual durational distinction between heavy syllables and a same-position unstressed CV for all syllable positions. I supported this weight criterion with phonetic data from Norwegian, showing that because final lengthening affects word-final syllables a syllable in final position must be longer than is required non-finally in order to be categorized as heavy. As discussed in §1.3, final lengthening is a cross-linguistic phenomenon, and so we can expect to find a similarly motivated account in other languages traditionally analyzed with final consonant extrametricality. For example, Ahn (2000) investigated the phonetic length of different syllable shapes in different positions in Jordanian Arabic, a language with CVC weight-asymmetry. As can be seen from the table in (1) (copied from Ahn 2000:118), Jordanian Arabic is subject to final lengthening.
Ahn’s focus was the placement of stress: she points out that placing stress on a final CVC would presumably further lengthen the vowel and jeopardize a vowel length contrast with non-final long vowels. The idea put forward is that a final CVC is not a good place for stress because final lengthening will result in the short vowel of a final CVC potentially reaching the duration of a long non-final vowel. Thus the comparison of syllables for stress assignment is made between positions and syllable weight does not directly play a role. The proposal made here is instead concerned with categorizing the weight of a syllable (which may have an effect on whether or not it bears stress) and does this with respect to a comparison of syllable durations within the same position. Notice that if we make a within-position comparison of the proportional increase of CV: over a same-position unstressed CV we find a fairly consistent increase across positions, despite the differences in raw duration.

(2) Proportional increase in Jordanian Arabic (based on data in (1))

<table>
<thead>
<tr>
<th></th>
<th>Final</th>
<th>Penult</th>
<th>Antepenult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stressed CV:</td>
<td>113%</td>
<td>110%</td>
<td>120%</td>
</tr>
<tr>
<td>Unstressed CV</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

It is striking that while the raw increase of a CV: is larger word-finally (92 ms. versus 72/70 ms. non-finally) the proportional increase over a same-position CV
is almost the same. This suggests that perceptual increase in duration between a CV: and an unstressed CV in the same position is consistent across syllable positions. Unfortunately only vowel lengths are given and so a comparison of the proportional rime length increase of a CVC over a same-position CV cannot be made so we cannot test whether the proposed theory of weight motivates the CVC weight asymmetry.

Proportional increase of a syllable’s rime over that of a CV syllable in the same position may not always be enough to categorize syllable weight. For example, duration alone may be insufficient to correctly categorize syllable weight in languages where CVC syllables with sonorant codas are heavy but those with obstruent codas are light. Thus, attention must be paid to the particular perceptual correlates for weight in a given language.

6.2 Final syllable and final foot extrametricality

The proposed reanalysis of final-consonant extrametricality does not rid the grammar of the need for NonFinality as many languages do not allow stress to fall on the final syllable and some do not allow stress to fall on a final foot. In pre-OT work the final syllable or foot of such languages was set apart from the metrical structure. In OT grammars, NonFinality ranked above Rightmost, in conjunction with the assumption that the language does not allow the final consonant to be exempt from lower prosodic structure, results in stressless final syllables. The constraint NonFinality may also be relativized to a foot (see, for example Hyde 2003) to duplicate the effect of final foot extrametricality. I
propose that an appeal to effects of final lengthening gives an alternative account and a motivated explanation for these cases.

There are several reasons why the final position may not be a perceptually good place for stress. If lengthening under stress is an important cue for stress in a language, placing the stressed syllable in a position that is already subject to phonetic length will make it hard for speakers to perceive the lengthening due to stress. The fact that final syllables are subject to word-final devoicing also suggests that length is not well perceived in final position (see Myers & Hansen forthcoming). Thus speakers of a language might find the final syllable a poor position for stress because increased phonetic duration due to stress is not easily perceived. The fact that final stress is avoided in such languages would then be analyzed as due to it being a poor place to perceive stress, rather than due to an avoidance of final stress per se. This accounts makes the prediction that languages in which phonetic duration is not a strong perceptual correlate of stress would be less likely to avoid placing stress on the final syllable.

This account explains why final stress is avoided, but not why we would find languages with trochaic feet behaving as though they regularly set the final syllable off from the metrical structure. I suggest a final right-aligned foot is avoided in these languages because final lengthening would cause it to be an uneven trochee. Hayes (1995) proposes that even trochees (LL) are preferred to uneven trochees (H)/(HL). Word-final lengthening would make a final (LL) foot, which non-finally would be a good even trochee, perceived as more like (LH), which is a terrible trochee. Thus considering the effect of final lengthening in conjunction with known foot-form preferences explains why some languages avoid forming a foot
over the final two syllables. The same explanation can be employed in considering languages that have been analyzed as having final foot extrametricality. Below I consider the data from Palestinian Arabic that leads Hayes (1995) to the conclusion that final feet are extrametrical.

If there is a heavy syllable within the final three syllables it receives stress. Like Norwegian, there is CVC weight asymmetry and a final syllable must be superheavy in order to count as heavy word-finally. (The separation of the final consonant in a final CVXC syllable prevents the final foot in such cases from being at the right edge.) The evidence for final foot extrametricality comes from words with final CV.CV.CV sequences. The pre-antepenult is stressed in words with four moras (CV.CV.CV.CV) while the antepenult is stressed in words with five moras (CVC.CV.CV.CV or CV.CV.CV.CV.CV). Hayes analyzes this as the effect of left-to-right footing in conjunction with final foot extrametricality. The footing of such templatic words is shown in (3). Feet are moraic trochees.

(3) Stress on CV.CV.CV-final words in Palestinian Arabic (Hayes 1995:127)

four moras  (CV.CV)<(CV.CV)

five moras  (CVC)(CV.CV)CV
(CV.CV)(CV.CV)CV

The crucial difference between words with four moras and those with five is that in the latter case the rightmost foot is not word-final and thus final foot extrametricality does not apply. Pre-antepenultimate stress is achieved in words of four moras because the rightmost foot will be at the right edge of the word and therefore the application of final foot extrametricality will cause it to be set off from the metrical structure of the word.
This analysis, while motivated by the data, has the problem of all analyses that appeal to extrametricality in that it does not offer any motivation for the absence of stress on a word-final constituent. I suggest that we can look again to perceptual factors to explain the pattern shown in (3). Considering that final lengthening at the word level causes final syllables to be notably longer than non-final syllables of the same shape we can see why feet at the right edge are ill-suited for stress. As discussed above, a trochaic foot formed around the final two light syllables would be a perceived as something like the strongly marked (\( \text{LH} \)) trochee since the weak syllable is subject to final lengthening. Thus the stress pattern in languages like Palestinian Arabic may be reanalyzed as avoiding word-final disyllabic trochaic feet.

6.3 Conclusion

Taking into account that a word-final syllable will be subject to final lengthening allows us to perceptually motivate the avoidance of final syllables and feet for primary stress. Considering that final syllables are subject to phonetic lengthening explains why a language would avoid placing stress on the final syllable and makes clear that a final disyllabic foot is an ill-formed trochee. The appeal to final lengthening explains why stress assignment behaves differently in word-final position, thus motivating the surface facts extrametricality and NONFINALITY have been formulated to describe.
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