Temporal Marking of Accents and Boundaries
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1. GENERAL INTRODUCTION

1.1. Prosodic Phonology

Speech does not merely consist of a string of segments, but is also characterized by suprasegmental features such as melody, rhythm and tempo. These features are called suprasegmental because they cannot be attributed to individual speech sounds, but are typically properties of longer stretches of speech. They are also referred to as prosodic features, where prosody is ‘the organizational structure of speech’ (Beckman, 1996). While the acoustic parameters involved (fundamental frequency, duration, amplitude, spectral tilt and segmental quality) also vary systematically from one segment to the other, only the patterns of these parameters that can best be accounted for by reference to higher-level structures belong to prosody (Shattuck-Hufnagel & Turk, 1996). Thus, prosody cannot be derived from the sequence of segments alone (van Heuven & Slijter, 1996). Conversely, prosodic structure is made up of the constituents needed to account for these acoustic patterns (Shattuck-Hufnagel & Turk, 1996).

Prosodic features have numerous linguistic functions, varying quite strongly across (groups of) languages. For example, different fundamental frequency patterns are used to distinguish lexical items from one another, just like phonemes, in tone languages such as Japanese and Mandarin Chinese. In stress-accent languages, on the other hand, changes in fundamental frequency constitute the melody or intonation of an entire utterance. In such languages, intonation is not used contrastively at the lexical level, but can only be used to make non-lexical contrasts such as that between declaratives and questions. Besides making such non-lexical contrasts, the main linguistic functions of prosodic features in these languages are to indicate which parts of the speech stream are most important, and to segment the continuous flow of speech into smaller units at several different levels (Cutler, 1991). In this thesis, we will be concerned only with these latter two uses of prosodic features in two stress-accent languages, English and Dutch. The boundaries indicated by prosodic features will be referred to as prosodic boundaries, and the units delimited by these boundaries as prosodic constituents. Units that are made salient by prosodic features, typically the syllable, are said to be prominent. The term accent is reserved for prominence at the phrasal level, marked by a conspicuous ‘accent-lending’ pitch movement.

Although syntax clearly imposes constraints on prosodic structure, the prosodic
constituency as indicated by prosodic features is not necessarily in accordance with the syntactic structure of an utterance (e.g. Nespor & Vogel, 1986). The growing number of discrepancies between syntactic and prosodic structure as more sentences were considered led to the development of theories incorporating a separate prosodic structure into the linguistic model (Selkirk, 1984; Nespor & Vogel, 1986; Hayes, 1989). Each prosodic constituent in this structure not only serves as a domain for phonetic processes, but also as the domain of application for phonological rules (Nespor & Vogel, 1986). Prosodic structure is therefore also referred to as phonological structure, and the domain of linguistics devoted to the study of this structure is called prosodic phonology.

Before turning to the main issues addressed in this thesis, i.e. the temporal marking of accents and boundaries, we will briefly explore what (kind of) factors are known to influence the position of boundaries and prominences. As far as prosodic boundaries are concerned, one major factor influencing their position is the morphosyntactic structure. For example, some syntactic constituents (parentheticals, tags etc.) obligatorily form a separate intonational phrase (Nespor & Vogel, 1986). Also, prosody can solve syntactic ambiguities by indicating which words are grouped more closely together (Lehiste et al., 1976), as shown in (1):

(1) a. He saw the girl [with the binoculars].
   b. He saw [the girl with the binoculars].

Other syntactic ambiguities, involving syntactic relations or functions, cannot be so easily disambiguated by prosody (Price et al., 1991), as the sentence in (2) exemplifies:

(2) The shooting of the hunters was terrible.

Apparently, the latter type of syntactic differences between sentences do not affect prosodic structure, and therefore cannot be differentiated in the speech signal.

Other factors determining the occurrence and position of prosodic boundaries include rate of speech (Caspers, 1994), and a tendency toward symmetry or balance (Gee & Grosjean, 1983; Ghini, 1993). Even though the influence of some of these factors has been the object of investigation, the picture we currently have on the precise influence of any one particular factor, and on the interaction between various factors, is far from complete. In fact, even though our understanding of prosodic constituency has increased substantially since prosodic phonology has become a separate component of linguistics, there is still no consensus on even the most basic
issue of how many types or levels of constituents we should distinguish.

One of the most important factors determining the position of the main prominence in an utterance is focus distribution, i.e. the location of important information (Baart, 1987). What the speaker regards as new information, in turn, is largely determined by the context in which an utterance is spoken. Other factors are also involved in determining which elements in the speech signal are prominent. For one thing, it is not just the main prominence in the utterance that we would like to capture; focus does not help us much in predicting the position of lower levels of prominence (e.g. at the word level). A lot of work has been done to incorporate the rhythmic character of speech into the prominence model, starting with Liberman (1975) and Liberman & Prince (1977). Focus and rhythmical principles, together with syntax and lexical stress positions, interact closely to give an utterance its prominence pattern (cf. Selkirk, 1984). While it is clear that prominence exists at several different levels, it is still unclear how these different levels should be analyzed, and how many levels should be distinguished.

The placement and number of prominences can also be influenced by a number of paralinguistic factors, such as the emotional state of the speaker, the surroundings, the relationship between speaker and hearer and other socio-cultural factors (van Bezooijen, 1984). These factors may also determine the way in which prominences are marked (e.g. the choice of a particular tune, the strength of each of the acoustic cues and/or their precise implementation; Mozziconacci, 1998). Once again, however, our understanding of prominence placement and its phonetic realisation is far from complete.

1.2. Temporal marking of accents and boundaries

The relative importance of each of the prosodic features (intonation, duration, pauses, amplitude, spectral quality and spectral balance) in marking the position of prosodic boundaries and prominences depends on several factors, such as constituent level (deeper boundaries are marked differently from shallower ones, and accent has different acoustic correlates than stress; cf. de Pijper & Sanderman, 1994 and Sluijter, 1995 respectively), context (from the segmental level up to the discourse level), and language-specific as well as speaker-dependent properties (e.g. Sanderman, 1996). Intonation, for example, plays a major role in marking the boundaries and heads of the larger constituents in the prosodic hierarchy, while those of lower-level constituents are not marked by intonation. Other prosodic features, such as spectral quality and balance, only serve as correlates for prominence (Sluijter, 1995), but not for
boundaries.

In this thesis, we will be concerned with the use of duration, a prosodic feature that is used to mark both prominences and boundaries (by increasing the phonetic duration of certain segments, i.e., by lengthening them). Lengthening at boundaries will be referred to as final lengthening, and lengthening of phrasal heads as accentual lengthening.

When investigating lengthening effects in speech, several possible questions which we should try to answer come to mind, such as:

1. When (under what conditions, or in what environment) does lengthening occur?
2. What is lengthened, i.e. what is the size of the lengthened domain?
3. How much is this domain lengthened?
4. How is the lengthening distributed over the lengthened domain?

The first of these questions is in a sense the primary issue, since any phenomenon must first be ‘localized’: the connection between segment duration and the position of boundaries or prominences needs to be established before the existence of final lengthening or accentual lengthening can be acknowledged. The first studies concerned with segment durations have therefore focused on determining when and where lengthening occurs (cf. Klatt, 1976).

The second question forms one of the main topics of the present thesis: we aim to specify rather precisely what the domain of final and accentual lengthening is in Dutch, i.e., to specify the size of the unit that is durationally affected under the influence of boundaries and accentuation. In the process, and somewhat implicitly, we may get some insight into the third question, too. Prior research on final lengthening in Dutch and English has shown that this lengthening effect is found primarily in the final syllable. We will investigate whether factors such as boundary depth, word stress, and final syllable structure influence the size of the domain of final lengthening in Dutch. Prior research on accentual lengthening suggests that Dutch and English may have different domains of accentual lengthening. This claim will be tested through an experiment on Dutch, which is designed specifically to allow cross-linguistic comparison with material already available on English. A comparison of lengthening effects in Dutch versus English forms the second main topic of this thesis; the final experiment described in this thesis involves a comparison of the interaction between final and accentual lengthening in Dutch and English. We will specify the research questions addressed in this thesis more precisely below, in the outline of the present study (§1.5).

There is one study on English which addresses the distribution of final and accentu-
al lengthening (question 4 above) within the final and accented syllable, and which will now be discussed in some detail, for future reference. This study makes it clear that the distribution of final lengthening is markedly different from that of accentual lengthening, and that this may be related to articulatory differences. Note that it addresses the distribution of these lengthening effects within the final/accented syllable only; it is not concerned with the question whether the domain of either of these lengthening effects may exceed the syllable.

The study at issue is reported on in various papers (Edwards & Beckman, 1988; Beckman & Edwards, 1990; Edwards, Beckman & Fletcher, 1991; Beckman, Edwards & Fletcher, 1992). The relevant utterances are given in (3) (from Beckman, Edwards & Fletcher, 1992):

(3)  
   a. Pop, opposing the question strongly, refused to answer it.  
   b. Poppa, posing the question loudly, refused to answer it.  
   c. Pop opposed the question strongly, and so refused to answer it.  
   d. Poppa posed the question loudly, and then refused to answer it.  

To study final lengthening, pop in (3a) can be compared with (3b) and (3c), differing from each other in the type of word in which the syllable pop is contained (monosyllabic vs. disyllabic) or in the presence vs. absence of an intonational phrase boundary following pop (presence is indicated by a comma). The syllable pa in sentences (3b) and (3d) also differ only in that the former is followed by an IP boundary and the latter is not.

Since in (3a,b), pop(pa) is the only word in the IP, these target words are assumed to be obligatorily pitch accented. To study the effects of accent, these target words are compared with the same words in (3c,d). A pitch accent on pop(pa) in (3c,d) is not impossible; therefore, when studying the effects of accent, only data from those speakers which left pop(pa) in (3c,d) unaccented were used.

As Edwards & Beckman (1988) show, a pitch accent increases a syllable’s overall sonority, but does not markedly change the shape of the sonority profile, nor the timing of the sonority peak in the stressed syllable. This implies that both the part preceding the sonority peak and the part following it are lengthened to an equal degree. This is in contrast with the effect of final position, which leads primarily to a change in shape of the final syllable’s sonority profile through lengthening of the second part of the syllable. The difference is schematically presented in (4):
In Beckman, Edwards & Fletcher's (1992) task-dynamic model, the closing gesture of an accented syllable is said to be **phased later** relative to the opening gesture than it is in unaccented syllables. The jaw then moves further in an accented syllable because the opening gesture is not truncated by the closing gesture. In final position, on the other hand, there is only a change in **articulator stiffness**; the phrase-final closing gesture is longer because it is less stiff, but the gesture is not larger or phased later (looking at its beginning point) than in a non-final syllable.

A discussion of other relevant literature on final and accentual lengthening requires some background knowledge, and an understanding of the terminology employed. It is therefore postponed until after the following section.

### 1.3. Theoretical background

As mentioned earlier, there is no general agreement within the field of prosodic phonology on issues such as the number and types of constituents that need to be distinguished, or how different levels or types of prominence should be analyzed. To make matters worse, terminology in this field is far from consistent: the same phenomenon may be referred to with different terms by different researchers, and a single term may be used across researchers to refer to different phenomena. This lack of consensus necessitates a definition of terms, in order to avoid misinterpretation and misunderstanding. In the sections that follow, several (phonological) notions that become relevant later in this thesis are discussed. First of all, in §1.3.1, an attempt is made to take the most recent and elaborate proposals on prosodic constituency together, in order to arrive at a superset of prosodic constituents which captures most of the units apparently involved in determining the way spoken utterances are realized. In §1.3.2, we will elaborate on those constituents in Dutch that are somehow problematic. We will need to refer back to these discussions of (Dutch) constituency when specifying boundary depth (Chapter 2), the (possible) domains that are lengthened due to a following boundary (Chapter 2) or a pitch accent (Chapter 3), and when
discussing previous literature. In §1.3.3, constraints on the hierarchical organisation of prosodic constituents will be briefly set out. Finally, prosodic prominences will be discussed in §1.3.4. These sections serve to give some general background knowledge.

### 1.3.1. Prosodic constituents: a general superset

In this section, we will discuss several terms used by different researchers for the prosodic constituents that have been proposed in the literature. For a more extensive review, the reader is referred to Shattuck-Hufnagel & Turk (1996). Constituents larger than the Utterance, such as the paragraph, are excluded from this discussion, primarily because they are not relevant for this thesis. The paragraph is also not known to serve as the domain of application of (segmental-)phonological rules (cf. Nespor & Vogel, 1986). Constituents above the level of the Utterance are often said to be part of ‘discourse structure’ rather than prosodic structure, even though they may also be marked by prosodic features (e.g. Lehiste, 1979; van Donzel, 1999).

At the top of the prosodic hierarchy, we find the Utterance (U), which is the largest domain of application of phonological rules (Selkirk, 1978, 1980; Nespor & Vogel, 1986; Hayes, 1989). It often corresponds to a single syntactic sentence, but may include two or more closely related sentences. In other theories, the Utterance is lacking, and the highest prosodic unit is the (Full) Intonational Phrase (Beckman & Pierrehumbert, 1986). According to Pierrehumbert (1980), the Intonational Phrase (IP) serves as the domain of a “perceptually coherent intonational contour”. Its relevance is widely acknowledged, and its boundaries are normally quite clear: its right edge is marked not only by a boundary marking pitch movement, but also by a relatively large amount of final lengthening (e.g. Klatt, 1976; see also §1.4.1 and Chapter 2 below).

The disagreement among researchers is largest below the level of the (Full) Intonational Phrase: Beckman & Pierrehumbert (1986) propose that a Full Intonational Phrase is parsed into one or more Intermediate Intonational Phrases, and Ladd (1986) raises the possibility of recursive Intonational Phrases, while in Nespor & Vogel (1986) and in Hayes (1989) the next lower unit is the Phonological Phrase. Selkirk (1980) proposes two types of Phonological Phrases, the Major Phrase and the Minor Phrase. Her Major Phrase may correspond to Beckman & Pierrehumbert’s Intermediate Intonational Phrase, and her Minor Phrase may best fit Nespor & Vogel’s Phonological Phrase or Clitic Group.

At this point in the hierarchy, there seem to be some cross-linguistic differences: the need for Nespor & Vogel’s Clitic Group seems obvious in Romance languages such
as Italian, but is not so clear in other languages such as Dutch (Booij, 1995; see also §1.3.2.2 below). The Accentual Phrase has been used to describe a unit in Japanese (Beckman & Pierrehumbert, 1986) and Korean (Jun, 1993) which is equal in size to or larger than a word in which no more than one pitch accent occurs, yet this unit might be specific to tone languages. Gussenhoven (1990) introduces the term Association Domain for a highly similar unit in English, i.e., a unit over which the tones of a pitch accent are distributed, yet he claims that this unit is determined by the structure of other prosodic units, and not itself part of prosodic structure (see also Gussenhoven & Rietveld, 1992). Existing cross-linguistic differences may be part of the reason for the lack of agreement concerning the prosodic units at these levels. Still, most theories concur in having two levels between the (Full) Intonational Phrase and the Prosodic Word.

The theories seem to come together again at the level of the Prosodic Word (PW), although definitions have differed somewhat (cf. Nespor & Vogel, 1986; Hayes, 1989; Selkirk, 1996). Definitions differ especially in the way or extent to which function words are parsed into Prosodic Words, an issue related to the type of constituent that is posited as the next higher level. There is also disagreement as to how different types of morphemes should be parsed. Nespor & Vogel (1986) allow for languages to differ in this respect.

Below the level of the Prosodic Word, we find the Foot (F) and the Syllable (o). Syllables consist of a vocalic nucleus (or syllabic sonorant) along with associated consonants to the left (onset consonants) and right (coda consonants) of this nucleus (cf. Kahn, 1976; Clements & Keyser, 1983; Harris, 1983). Syllables are combined into Feet, which contain at most one lexically stressed syllable, followed or preceded by zero, one or in some formulations two weak syllables (Liberman & Prince, 1977; Kiparsky, 1979; Hayes, 1981). The importance of the Foot in describing the prosodic structure of an utterance lies mainly in determining lexical (primary and secondary) stress positions in the word (Nespor & Vogel, 1986). Its definition, which allows for reduced syllables to occur on only one side of the stressed syllable within a particular language, ensures a rhythmical pattern which is typical of many, if not all stress-accent languages.

Finally, the phonological weight of a syllable, essential for the determination of stress placement in many languages, may be expressed in terms of the number of moras within the syllable. The existence of the mora is uncontroversial in languages such as Japanese, which is even called a moraic language, but may not be needed in the description of other (weight-insensitive) languages.

In all, we arrive at a prosodic hierarchy consisting of the following constituents (see Shattuck-Hufnagel & Turk, 1996 for a similar comparison):
In this section, we will elaborate on the definition of some prosodic constituents specifically for Dutch. We will adopt the terminology of Nespor & Vogel (1986) and discuss the Phonological Phrase, the Clitic Group, the Prosodic Word and the Foot in more detail; these four constituents require a language-specific definition, and/or are problematic for Dutch. In the case of unsettled problems, we will specify how these are dealt with in other parts of this thesis. Although the Intonational Phrase and the Utterance are also highly relevant in the chapters that follow, they are not discussed in this section, since they are neither language-specific nor problematic (at least for our purposes).

1.3.2.1. The Phonological Phrase

The Phonological Phrase is the constituent directly below the Intonational Phrase, and groups together a number of words into phrases. In Nespor & Vogel (1986), the Phonological Phrase is defined in syntactic terms as follows ($\phi=$Phonological Phrase, $C=$Clitic group):

\begin{equation}
\phi\text{-domain}
\end{equation}

The domain of $\phi$ consists of a $C$ which contains a lexical head ($X$) and all Cs on its nonrecursive side up to the $C$ that contains another head outside of the maximal projection of $X$. 

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1.3.2. Some prosodic constituents in Dutch

In this section, we will elaborate on the definition of some prosodic constituents specifically for Dutch. We will adopt the terminology of Nespor & Vogel (1986) and discuss the Phonological Phrase, the Clitic Group, the Prosodic Word and the Foot in more detail; these four constituents require a language-specific definition, and/or are problematic for Dutch. In the case of unsettled problems, we will specify how these are dealt with in other parts of this thesis. Although the Intonational Phrase and the Utterance are also highly relevant in the chapters that follow, they are not discussed in this section, since they are neither language-specific nor problematic (at least for our purposes).
In Nespor & Vogel (1986), Dutch is noted as a problematic case for which the definition might be more complex. The problem is that it is not clear for Dutch what the recursive side of a head is: in Dutch, a node can expand either to the left or to the right of the head of a phrase, as illustrated in (7) (from Nespor & Vogel 1986, p. 186, footnote 2):

(7) a. Het nog te lezen boek ligt op tafel.
    the yet to read book lies on table
    ‘The book that is still to be read is on the table’.

b. Ik denk dat ik een boek zal lezen.
    I think that I a book shall read
    ‘I think I will read a book’.

In (7a), the complement (underlined) stands to the left of the phrasal head boek ‘book’, while in (7b) the complement stands to the right of the phrasal head denk ‘think’. The relative freedom of the head-complement ordering depends partly on the type of syntactic phrase. NPs are said to be uniformly right recursive (despite the counterexample in (7a)!), while VP’s regularly have complements on either side (Bennis & Hoekstra, 1989; Nespor, Guasti & Christophe, 1996).

To solve the problem, we could point out that despite the existence of recursivity in both directions, Dutch has been assumed to have an unmarked direction of recursion, namely rightward. Both Neijt (1984) and Berendsen (1986), on the basis of Dutch stress phenomena and Dutch cliticization, respectively, consider Dutch to be a right recursive language with left recursive structures as a marked option. Nespor & Vogel (1986) suggest that ‘the nonrecursive side’ should be interpreted as the unmarked nonrecursive side; should a complement stand to this side in a marked case, it is still joined into the phonological phrase with the head. Hence, Dutch may also follow this option if it has an unmarked recursive side, although this may be a position more defendable for some syntactic phrase types (e.g. NP’s) than others (e.g. VP’s). The above solution is employed by Menert (1994). Alternatively, Nespor, Guasti & Christophe (1996) suggest that what is the (non-)recursive side of the head need not be established for the whole language, but can be determined for specific phrases. On the basis of Dutch data, they argue that such an analysis per phrase type is supported by the location of the main prominence inside φ. So, the main prominence within a noun phrase (right recursive) falls on the rightmost element, while the position of the main prominence within a verb phrase varies according to the direction of expansion.

The phonological phrase is the smallest prosodic constituent that may undergo
restructuring. According to Nespor & Vogel, $\phi$-restructuring is allowed in certain languages and in certain circumstances, and they describe this restructuring rule as follows:

(8) $\phi$-restructuring (optional)

A nonbranching $\phi$ which is the first complement of $X$ on its recursive side is joined into the $\phi$ that contains $X$.

With this restructuring rule, short, non-branching $\phi$s are avoided. Others have proposed that the possibility of restructuring depends not so much on branchingness, but simply on the length of the constituents involved (e.g. Ghini, 1993). In many cases, this leads to the same predictions. Again, the use of the notion 'recursive side' makes the definition in (8) problematic for Dutch, especially in the case of VPs.

For our purposes, we need to make sure that no restructuring can apply at the position where we posit a phonological phrase boundary. Also, we should make as few assumptions as possible about what the recursive side is in Dutch, for the language in general or for a particular phrase type; only the right recursiveness of noun phrases seems an acceptable assumption. We constructed our material such that a branching noun phrase (with a determiner, an adjective and a noun) is followed by a verb, and each is outside of the maximal projection of the other. Regardless of whether we assume that Dutch is right recursive in the unmarked case and hence will only join material to the left of any head into a phonological phrase, or if we assume that this direction is determined per phrase type, a noun can be assumed to form one phonological phrase with material to its left within its maximal projection (i.e. with the determiner and adjective). The length and branchingness of this phonological phrase then excludes restructuring with the verb into one phonological phrase, regardless of whether the noun phrase is on the recursive side of the verb or not. In this way, there is a phonological phrase break between the noun and the verb under any analysis.

1.3.2.2. The Clitic Group

The Clitic Group is a constituent which groups together a content word with any neighbouring function words. It was first proposed by Hayes (1989) for English, and adopted by Nespor & Vogel (1986), whose definition is given in (9):
CLITIC GROUP FORMATION

C DOMAIN

The domain of C consists of a prosodic word containing an independent (i.e. nonclitic) word plus any adjacent prosodic words containing

a. a directional clitic, or

b. a clitic such that there is no possible host with which it shares more category memberships.

The Clitic Group has proved especially useful for the description of phenomena in Romance languages such as Italian and Greek. These languages have distinct stressed and unstressed forms for many of their function words, particularly for personal pronouns, and the unstressed forms are not just reduced forms of their stressed counterparts (as in many Germanic languages), but are quite different. In Italian, their clitic nature is often reflected in spelling: a sequence of two unstressed pronouns is often merged into one orthographic word, and when pronouns follow the verb they are written as one word with the verb (except for loro 'them', the only disyllabic personal pronoun). These properties of Italian function words are illustrated in the following example (the underlined clitic in (10a) corresponds to the underlined stressed pronoun in (10b)):

(10) a. indicaglielo         b. indicalo a lui
    indicate-him-it        indicate-it to him
    ‘indicate it to him’    ‘indicate it to him’

So, cliticized (unstressed) function words are quite easily distinguished from their non-cliticized (stressed) counterparts in Italian. In Dutch and English, however, it is much harder to establish whether cliticization takes place or not. While many function words do have a strong and a weak form (Booij, 1995), the relation between these forms and their clitic status is not as straightforward as in languages such as Italian. Booij (1995) states that all unstressed and/or weak forms should be qualified as clitics, yet this terminology leads to ‘clitics that are not cliticized’; the weak forms do not necessarily cliticize, since quite a number of rules applying within host+clitic combinations are not obligatory (see also Gussenhoven, 1985). Furthermore, the strong forms of Dutch function words may also be used in unstressed positions (Booij, 1995), so there is no clear correspondence between strong-weak forms on the one hand and stressed-unstressed position on the other. What can complicate matters further is that nearly all weak forms are reduced forms of their strong counterparts, with the vowel reduced to a schwa or deleted altogether, and sometimes with deletion
of the initial consonant (especially /h/). This resemblance between the weak and strong forms, the occurrence of both in unstressed positions, and the existence of ‘intermediate’ reduced forms (e.g. het ‘the, it’ can be realized as [het], [hat], [at] or [t]), can make it hard to distinguish between strong and weak forms in actual speech.

Dutch not only has a problem in classifying function words a priori as a clitic or a non-clitic, but also has a problem assigning them the status of a prosodic word, as Nespor & Vogel (1986) do for Italian clitics in order to join them into a Clitic Group with a content word while satisfying the Strict Layer Hypothesis (see §1.3.3 below). Due to the reduced shape of Dutch weak forms, all except ie (‘he’) and ik (‘I’) have schwa as their only vowel (or no vowel at all), which means that they cannot be a separate prosodic word (see §1.3.2.3 below). Booij (1995) argues that Dutch proclitics are “Chomsky-adjoined” to the prosodic word, and enclitics are “Chomsky-adjoined” to the foot, as illustrated in (11):

<table>
<thead>
<tr>
<th>(11)</th>
<th>a. PW</th>
<th>b. PW</th>
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<td>/</td>
<td></td>
<td></td>
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<tr>
<td>σ PW</td>
<td></td>
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<td>(proclitic)</td>
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<td>F</td>
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<tr>
<td>F</td>
<td>σ</td>
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<td></td>
<td>(enclitic)</td>
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<tr>
<td>σ</td>
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</tbody>
</table>

Such constructions violate the Strict Layer Hypothesis, but in a restricted type of way (see §1.3.3 below). Under such an analysis, the Clitic Group has no role in the Dutch prosodic hierarchy, since clitics are not integrated into prosodic structure by forming a separate constituent above the prosodic word.¹

Summarizing, Dutch function words optionally form one unit with a preceding or following host, and if they do, they are integrated into prosodic structure within or below the level of the prosodic word. The Clitic Group is therefore not included as a boundary type in Chapter 2. In Chapter 3, the durational behaviour of function words is examined, precisely to see if they are incorporated into a following or preceding word where the spreading of accentual lengthening is concerned.

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¹ Helsloot (1995), in a metrical framework, even precludes the clitic group as a separate level for Italian, based on the finding that the clitic group has no rhythmic properties of its own. She states that “phonological phenomena which are argued to provide positive evidence in favor of the clitic group, allow also for an analysis in terms of prosodic words and/or phonological phrases” (Helsloot 1995, p. 15, footnote 3).
1.3.2.3. The Prosodic Word

Below the level of the Clitic Group, we find the prosodic word. The prosodic word may correspond to the terminal elements of the syntactic tree in some languages, yet in Nespor & Vogel (1986), Dutch is used as an example of a language in which the prosodic word is smaller than the syntactic word. On the basis of the claim that the prosodic word is the domain of syllabification, coordination reduction and r-coloring in Dutch, Nespor & Vogel conclude that each member of a compound must form a separate prosodic word. For example, a stem-final consonant which becomes intervocalic due to compounding (e.g. *straat-arm* ‘very poor’) is not resyllabified, indicating that there is an intervening prosodic word boundary which blocks the application of resyllabification. Furthermore, some types of suffixes behave as if they were independent prosodic words too, in that they do not participate in resyllabification. These are assumed to be marked in the lexicon with a diacritic feature. Nespor & Vogel’s definition of the prosodic word domain is specifically refined to accommodate the case of Dutch. The option for prosodic word formation found in Dutch is given in (12):

(12) Prosodic Word Formation

\[ w \text{ domain} \]

- The domain of \( w \) consists of
  - a stem;
  - any element identified by specific phonological and/or morphological criteria;
  - any element marked with a diacritic [+W].

Booij (1995) notes that a prosodic word in Dutch needs to contain at least one syllable with a full vowel, since otherwise there is no syllable available for the location of the main stress. Words with a schwa as their only vowel, i.e. many of the reduced forms of function words, can therefore not form a prosodic word by themselves. When a function word is in focus, it will generally appear in its strong form, with a full vowel, so that it can form a legitimate prosodic word (provided that there is such a strong form; in the case of focus on the determiner *de* ‘the’, which has no such strong form, the pitch accent will have to be realized on a schwa).

1.3.2.4. The Foot

According to Hayes (1981), languages may be classified as having either binary feet, consisting of two syllables each, or unbounded feet, consisting of any number of syllables, and as being sensitive to syllable weight (quantity-sensitive) or not
(quantity-insensitive). According to work on Dutch phonology, Dutch has binary, trochaic (i.e. left-dominant) feet and they are quantity-sensitive (van der Hulst, 1984). Dutch syllables can be ordered along a weight scale according to the segments in their rhyme, as is proposed in van der Hulst (1984):

\[ (13) \text{schwa} \ VV \ VC \ VCC \ VVC \]

increasing weight →

Only the lightest of these may occur in the weak position of a foot. In Kager’s (1989) metrical analysis (see §1.3.4 below) of stress in Dutch, the following quantity-sensitive rule is formulated:

\[ (14) \text{Inherent stress by syllable weight (Kager, 1989):} \]

A heavy (closed, diphthongal) syllable is aligned with a line 1 grid element.

Similarly, Booij (1995) defines the essential part of the Main Stress Rule for Dutch as in (15):

\[ (15) \text{Main Stress Rule, part (a) (Booij, 1995):} \]

Create a left-dominant foot (*_ ) in the domain of the prosodic word, from right to left, in which the trough (_ ) does not dominate closed syllables or diphthongs. Otherwise, create a monosyllabic foot (*).

These (stress-based) rules specify that syllables which are closed (i.e. end in a consonant) or end in a diphthong form a foot by themselves, while word-final syllables ending in a schwa or a long vowel lead to the creation of a disyllabic final foot. However, the foot structure of words with a final VC-rhyme is somewhat problematic. In order to derive the dominant pattern of Dutch main stress, stress-based analyses such as the above (Kager, 1989 and Booij, 1995) need to mark a word-final syllable with a VC-rhyme as extrametrical, so that it does not receive primary stress. Gussenhoven (1993), on the other hand, gives an analysis of Dutch feet based on segmental and intonational facts, in which all words with penultimate lexical stress are said to have a final disyllabic foot, including those with a final closed (VC) syllable.

In Chapter 2, some test words are needed that have a final disyllabic foot. Only words with a word-final schwa or a word-final long vowel (and penultimate stress) have a final disyllabic foot according to both of the above analyses (Kager/Booij, and Gussenhoven). There is one other syllable type in Dutch, however, that has not been
mentioned in the above discussion: Dutch may have syllables with a schwa and a coda consonant (e.g. *bezem* /be:zam/, 'broom'). In Gussenhoven's (1993) analysis, this word forms one foot. Although the /m/ in this example makes the final syllable closed, this syllable should not be parsed into a separate foot in Booij's (1995) analysis either: a syllable with a schwa as nucleus cannot be the head of a foot, since it is always unstressed (van der Hulst, 1984; Booij, 1995). It must therefore be in the weak position of the foot, and not form a foot by itself. A word-final disyllabic foot can therefore also end with a schwa plus coda consonant in Dutch.

1.3.3. The hierarchical structuring of prosodic constituents

In contrast to syntactic structure, where a constituent may be parsed into constituents of many different types at the next level down, including constituents of its own type, prosodic structure is hierarchically organised such that a constituent at one level in the hierarchy is composed exclusively of one or more constituents from the next level down in the hierarchy, i.e., they are all of the same type (Nespor & Vogel, 1986). This generalization has been formalized as the Strict Layer Hypothesis. It prevents nesting of phrases, such as a Phonological Phrase embedded in another Phonological Phrase, and it rules out e.g. having a Phonological Phrase dominated directly by U, without an intervening Intonational Phrase. Nespor & Vogel's formulation is given in (16):

\[(16) \textit{The Strict Layer Hypothesis (SLH)}\]

1. A given nonterminal unit of the prosodic hierarchy, \(X_p\), is composed of one or more units of the immediately lower category, \(X_{p-1}\).

2. A unit of a given level of the hierarchy is exhaustively contained in the superordinate unit of which it is a part.

However, according to several researchers, this generalization is too strict. Ladd (1986), for example, sees no principled reason to restrict the number of levels in the prosodic hierarchy, and proposes to allow for a recursive prosodic structure. Ladd & Campbell (1991) argue for so-called Compound Prosodic Domains, which allow prosodic boundaries of the same type to be realized with different strengths. In the same vein, Drescher (1994) claims that the further levels of structure he encountered in the Tiberian Hebrew system of accents should not be considered new levels of the prosodic hierarchy, since they do not form domains for phonological rules. Rather, he argues that further hierarchical distinctions, relevant for phonetic effects but not for
phonology, are nested within the existing levels of the prosodic hierarchy (as constituents of the $X_w$ type).

The Strict Layer Hypothesis is also violated in Booij’s analysis of clitics (see (11) above). In (11a), a syllable is directly dominated by a prosodic word, i.e., the level of the foot is skipped. Furthermore, a prosodic word dominates another prosodic word. Others have also proposed structures in which a syllable is not parsed into a foot, but is immediately dominated by a prosodic word (e.g. Hayes, 1995; Kager, 1993; McCarthy & Prince, 1993). In the configuration in (11b), no levels are skipped, but still it constitutes a violation of the Strict Layer Hypothesis because a lower foot is nested within a higher foot.

In order to allow for cases where certain aspects of the Strict Layer Hypothesis are violated, the Strict Layer Hypothesis has been broken down into a set of four violable constraints (Selkirk, 1996), in an Optimality Theory framework (Itō & Mester, 1992; Prince & Smolenski, 1993). These constraints are:

(I) Layeredness:
A constituent of level $C_j$ in the prosodic hierarchy may not dominate a constituent of level $C_{j,n}$ (i.e. of a higher level)

(II) Headedness:
A constituent of level $C_j$ in the prosodic hierarchy must dominate a constituent of level $C_{j,1}$ (i.e. of the next level down), if there is such a level

(III) Exhaustivity:
A constituent of level $C_j$ in the prosodic hierarchy may not dominate a constituent of level $C_{j,(1+n)}$ (i.e. of more than one level down)

(IV) Nonrecursivity:
A constituent of level $C_j$ in the prosodic hierarchy may not dominate a constituent of the same level $C_j$

While the first two are not known to be violated, both Exhaustivity and Nonrecursivity are violated in constructions as in (11a), and Nonrecursivity is violated in (11b) and in Ladd’s (1986) proposal.

1.3.4. Prominences

Terminology in the field of prosody has been notoriously inconsistent. Beside the fact that constituents such as ‘phrase’, ‘word’ and ‘foot’ have received so many different definitions, terms such as ‘metrical’, and in particular ‘accent’ and ‘stress’ have been used to mean many different things. I will limit the use of the term ‘stress’ to refer to
lexical stress. Where necessary, the terms ‘primary stress’ and ‘secondary stress’ will be employed, both referring to prominence at the word level. Prominence at the intonational phrase level will be called ‘(pitch) accent’, referring to the conspicuous pitch movement marking prominences of this type. Again, occasionally further distinctions within this type of prominence may be made, such as the distinction between nuclear and non-nuclear pitch accents. The term ‘prominence’ will be used to refer to a generic quality shared by all levels (i.e., it could be described as relative salience).

In the generative approach of the sixties, higher levels of prominence were assigned to the nuclear element of higher-level constituents, which, due to the unbounded nature of syntactic structures, leads to a theoretically unbounded number of possible degrees of prominence. Perceptually, however, there is only a limited number of distinguishable prominence levels (Lieberman, 1960). An alternative analysis and notational device for prominence distinctions is the metrical grid (Liberman & Prince, 1977), further developed by Hayes (1983), Prince (1983) and Selkirk (1984), in which there is one column for each syllable and one row for each level of prominence on top of the string of syllables. The grid has proved especially useful in stating rhythmical principles and adjustments.

Others have proposed a four-level prominence system (Bolinger, 1958, 1965; Vanderslice & Ladefoged, 1972; Beckman & Edwards, 1994). These four levels can be described as:

(i) Nuclear accented stressed syllable
(ii) Non-nuclear accented stressed syllable
(iii) Non-accented stressed syllable
(iv) Unstressed (reduced) syllable

In Vanderslice & Ladefoged (1972) and Beckman & Edwards (1994), these levels are analyzed not as four levels within one unitary dimension, but as three different types of prominence ((iv) is not prominent). Such an analysis is able to account better for the fact that prominence distinctions at one level are marked by different (sets of) cues than at another level.

Returning to some early generative principles, the different kinds of prominence may be said to correspond to the heads of different constituents in the prosodic hierarchy. In Beckman & Edwards (1994), the nuclear accented syllable is analyzed as the head of the intonational phrase, and the stressed syllable (primary or secondary) as the head of the foot. So far, the analysis of prominences as the head of a particular constituent is not problematic, and it will be adopted here for these two
levels. However, as Shattuck-Hufnagel (1994) notes, it is not clear what the non-nuclear accented syllable should be the head of in such an analysis, only that it must be the head of a unit between the intonational phrase and the foot. Clearly, a one-to-one linking between prominence types and constituents of which they are the head requires more than three types of prominence. In fact, a four-way distinction may also be too restricted to describe all levels of prominence that are perceptually distinguished. We may need to extend the analysis of prominences if it turns out that pitch accents can signal more than the two different levels of prominence already included (nuclear vs. non-nuclear), or if we want to include a distinction between primary and secondary word stress. In any case, prominence exists at several different types of levels, but it is still unclear exactly how many levels should be distinguished, and how they can be most adequately described.

We now return to the main topics of this thesis, with a discussion of some relevant literature on final and accentual lengthening.

1.4. Prior research on lengthening effects

1.4.1. Final lengthening

In the past, final lengthening was thought to coincide with syntactic boundaries (e.g. Klatt, 1975). With the development of prosodic phonology, it turned out that the application and patterns of what we now call 'prosodic features' are better described in terms of prosodic constituents, rather than syntactic ones (Gee & Grosjean, 1983; Ferreira, 1991). Final lengthening is a firmly established and widely attested phenomenon at the intonational phrase or utterance level (Vaissière, 1983; Maddieson, 1997). Early work establishing final lengthening in production was often part of more general studies investigating segment duration (e.g. Nooteboom, 1972; Oller, 1973; Klatt, 1975; Cooper & Paccia-Cooper, 1980; Crystal & House, 1988). In Klatt’s (1975) work on American English vowel durations, the final vowel of a (syntactic) sentence was found to be on average 30% (40 ms) longer than the median for that vowel type. Beside a very clear effect at utterance boundaries, some degree of lengthening has also been observed at lower level boundaries. Just what type of constituents are marked in this way is still a matter of debate, but the relationship between the amount of final lengthening and the depth of the boundary involved is undeniable (cf., among others, Cooper & Paccia-Cooper, 1980; Ladd, 1986; Wightman et al., 1992).
Perception experiments have also shown a correspondence between perceived boundary strength and amount of final lengthening. Gussenhoven & Rietveld (1992) tested whether English listeners require more final lengthening at deeper prosodic boundaries, using speech in which the duration of the rhyme of the final syllable was synthetically varied. Their material contained foot boundaries, prosodic word boundaries, phonological phrase boundaries and intonational phrase boundaries. They found that English listeners indeed prefer more final lengthening at deeper prosodic boundaries, i.e., that the ideal duration of a final rhyme is longest at an intonational phrase boundary and shortest at a foot boundary. Thus, according to the listener, a deeper boundary should be marked by more final lengthening, and this is indeed what we find in production.

The relationship between boundary depth and amount of final lengthening in production and perception is elegantly shown for Dutch by Nooteboom & Doodeman (1980). They still describe their boundaries in syntactic terms, but these can easily be translated into prosodic ones. They constructed sentences which semantically and syntactically allowed for either the word *tak* /taik/ ‘branch’ or the word *taak* /taik/ ‘task’ to occur in a certain position. This position was followed by syntactic boundaries of various depths. In a production experiment, the duration of each of these vowels was significantly affected by the type of boundary following the word. In a number of perception experiments, the length of the vowel in the target word was synthetically varied, and listeners had to indicate whether they heard *tak* or *taak* in a binary forced-choice identification task. Their results show that the listener’s internal criterion for this short-long vowel distinction is adjusted according to the type of boundary that follows; the expected vowel durations are longer when followed by a deeper boundary.

As discussed earlier (§1.2), Edwards & Beckman (1988) showed that for final lengthening the longer acoustic durations are associated with a disproportionate lengthening of the second part of the final syllable. Other experiments have shown that final lengthening is a progressive effect, getting stronger as the distance from the boundary is smaller (Kohler, 1983; Berkovits, 1994; Hofhuis et al., 1995).

An American English database study by Wightman et al. (1992) confirms that the amount of final lengthening is related to boundary depth in production. Moreover, their results seem to indicate that the produced lengthening associated with a boundary is confined to the rhyme of the final syllable, as is assumed in numerous perception studies (e.g. Gussenhoven & Rietveld, 1992) and also in English text-to-speech programs. However, Wightman et al.’s (1992) analysis does not consider all possible domains, but only four, namely the final coda consonants (if any), the vowel of the final syllable, any segments between the last stressed vowel and the vowel of the final
syllable, and the last stressed vowel itself. This leaves open the possibility that in some cases, e.g. before deep prosodic boundaries, more than the rhyme is lengthened (but less than the larger domains they looked at; see description above), e.g. the whole final syllable or the final (disyllabic) foot.

Another problem with the study by Wightman et al., as often with database studies, is that factors which may influence the effect under observation might have been overlooked. For example, the structure of the final word may play a role. This would be the case if the final foot is the domain of final lengthening for a certain type of prosodic boundary, because the foot may consist of one or two syllables, depending mainly on the segmental structure of the last syllable.

A production experiment by Hofhuis (in prep.) in fact shows that the domain of final lengthening in Dutch may indeed exceed the final syllable at least under certain circumstances. Her data consist of monosyllabic and disyllabic words, where the latter differ from the former only in the addition of a word-final schwa (e.g. maat /maːt/ - mate /mɑːt/), occurring at five different boundaries. In the disyllabic words, an effect of boundary depth was found not only in the final syllable, but also in the penultimate rhyme (a full vowel), and sometimes even in the penultimate onset (i.e. in the whole word). However, using only schwa-final disyllabic words (forming one foot) makes it impossible to differentiate between foot structure or vowel quality as the factor allowing the domain of final lengthening to exceed the final syllable. Furthermore, Hofhuis' results can be expressed as lengthening of the final two syllables, the final foot, or the whole word, or as the last stressed syllable being the onset of final lengthening. Thus, the question of what the domain of final lengthening is and which factor(s) may influence the size of this domain still remains open to some extent. It is these questions which will be addressed in Chapter 2.

1.4.2. Accentual lengthening

A lot of work has been done on the acoustic correlates of stress and accent, even though they have not always been consistently distinguished from one another. Fry (1955, 1958) studied the relative importance of accentual cues in English, and found that pitch is the primary cue for accent, followed by duration, intensity and vowel quality. Sluijter (1995), studying stressed syllables with and without pitch accents in English and Dutch, showed that pitch excursions are absent from unaccented words, i.e., stressed syllables are not marked by pitch when they are unaccented. Duration, on the other hand, has proved to be a reliable correlate of both stress and accent, i.e. for prominence at the word level and at the intonational phrase level. In this thesis, however, we will only be concerned with lengthening associated with a pitch accent,
i.e. marking prominence at the phrasal level. In accordance with our terminology set out in §1.3.4, we will use the term accentual lengthening to refer to lengthening as a (secondary) cue to phrasal prominence (i.e. accent, primarily marked by a pitch movement).

This definition of accentual lengthening entails that we will not be concerned with the question of where (in what environment) this phenomenon occurs; as a secondary cue to accent, it occurs in the vicinity of an accent-lending pitch movement. Since focus distribution is the main factor influencing the position of phrasal prominence, it indirectly largely determines the occurrence of accentual lengthening as well.

Looking at accentual lengthening within the syllable, Edwards & Beckman (1988) found that both the opening and the closing gesture of the syllable are affected (cf. §1.2). Research by Eefting (1991) on Dutch confirms that all segments within the accented syllable are lengthened by a pitch accent. Outside the accented syllable, other syllables may be affected as well; several studies on Dutch have shown that all syllables within the accented word are lengthened (Nooteboom, 1972; Eefting, 1991; Sluijter, 1995). Accented words are generally lengthened by some 15-20%, and the lengthening is said to be distributed fairly evenly across all syllables in the word. This linear expansion of the entire word does not interfere with the durational effect of word stress, but is independent of it; the effects are additive.

Studies on American English by Turk & Sawusch (1997) suggest that the domain of accentual lengthening begins with the accented syllable and can include an unstressed syllable following the accented syllable within the word. Unstressed syllables preceding the accented syllable were not durationally affected by the accent, which led Turk & Sawusch (1997) to conclude that the domain of accentual lengthening in English may be the foot. This conclusion is in contrast with what is claimed for Dutch, where the domain of accentual lengthening is said to be the entire word, thus including unstressed syllables to the left of the accent (Nooteboom, 1972; Eefting, 1991; Sluijter, 1995). However, the type of material and the experimental conditions in the Dutch and English experiments were not identical. Thus, whether the different findings are experimental artifacts or involve a real difference is still at issue. Subsequent research in Scottish English (Turk & White, 1999) in fact suggests that unstressed syllables to the left of the accented syllable are also lengthened when compared to an unaccented condition (for some subjects), although not as much as those to the right. In order to allow for a better cross-linguistic comparison, the experimental design employed for English (Turk & Sawusch, 1997) was applied to Dutch in the experiments described in Chapter 3. In this chapter, prior to the report of our own experiments, the exact mismatches between the previous Dutch and English studies will be expounded in more detail.
1.5. Outline of the present study

This thesis contains the description of a series of experiments concerned with durational marking of accents and boundaries.

In Chapter 2, we will discuss experiments involving final lengthening. These experiments are on Dutch only. Our primary goal in this chapter is to specify what the domain of final lengthening is, i.e., which segments are lengthened due to a following boundary. More specifically, we aim to answer the following research questions:

- What is the relationship between boundary depth and the domain of final lengthening?
- Do stress and/or the structure of the final syllable/word have an effect on the domain of final lengthening?

To answer these questions, two production experiments are carried out. The pilot study serves both to check whether the experimental task is appropriate for our purposes, and to provide ideas for the materials needed in the main experiment. In the main experiment, we are in search of factors influencing the domain of final lengthening. Both experiments will be described in turn.

Following these production experiments, two perception experiments were run, using material obtained in the production experiments. These are designed to answer the following research questions:

- To what extent are the durational differences found in production used in boundary perception?
- Are listeners sensitive to differences in the size of the domain over which a certain amount of lengthening is spread?

The results of these perception experiments will be related to the interpretation of the main findings in the production in the final section of Chapter 2.

In Chapter 3 we will discuss work on the domain of accentual lengthening. The production experiments described in this chapter explicitly require an elaborate discussion of previous work in this area, since they are based on the observation that the experimental paradigms used for English and Dutch are different. These differences in design may or may not be the cause of the different conclusions which have been drawn for these two strongly related languages. Thus, although the actual experiments are on Dutch, this chapter has a strong comparative nature: the general picture on the domain and distribution of accentual lengthening in Dutch emerging
from these and prior experiments will be compared to the general picture on accentual lengthening in English obtained by Turk and her co-workers. The material was set up not only to allow for better cross-linguistic comparison, but also to investigate in more detail what the domain of accentual lengthening is, i.e., which type of boundary (or boundaries) blocks or attenuates the spreading of accentual lengthening. Thus, the questions addressed in Chapter 3 can be summarized as follows:

- Do Dutch and English have different domains of accentual lengthening, as claimed in the literature, or were the different conclusions for these two languages due to differences in experimental design?
- Which type of boundary/boundaries influence the spreading of accentual lengthening in Dutch?

During the studies on the domain of accentual lengthening in Dutch and English, we stumbled across what appeared to be a language-specific interaction between final lengthening and accentual lengthening. In Dutch, the amount of accentual lengthening on an accented syllable seemed to depend on its position within the phrase, in that it is much less when the syllable is in phrase-final position (i.e., where it is already subject to final lengthening). In English, we found no such effect, suggesting that in this language final lengthening and accentual lengthening are completely additive. These observations needed independent evidence, which was obtained in a set of production experiments run for both English and Dutch. These experiments will be reported on in Chapter 4, and address the following questions:

- Is there an interaction between final lengthening and accentual lengthening in Dutch?
- Is Dutch different from English with respect to the above?

The study is concluded in Chapter 5 with a summary of the main findings and conclusions, a discussion of the implications of our work in a wider scope, and some suggestions for further research.