Chapter 5

General discussion

5.1 Introduction

Domain-edge and domain-span timing processes at the word level and the utterance level are examined in Experiment 2, presented in Chapter 4, as is the durational effect of pitch accent and the interaction of pitch accent with edge and span processes. There is support for domain-edge processes: in particular, word-initial lengthening and utterance-final lengthening. Results also suggest that the syllable onset—the locus of word-initial lengthening—may be further lengthened phrase initially (for example, phonological-phrase-initially); however, there is an absence, for certain onset consonants, of any domain-initial lengthening effect utterance-initially. There is little support for domain-span processes at the word level and the utterance level, although there is evidence of a domain-span process at the word-rhyme level. The locus of accentual lengthening is shown to be the word, with the greatest lengthening effects observed word-initially and word-finally. The variation in accentual lengthening of the primary stressed syllable according to word length accounts for previously-observed polysyllabic shortening, an apparent domain-span process at the word level.

The evidence for these processes is considered further in this chapter: in particular, possible interpretations are suggested where the findings of Experiment 2 are different from those of previous studies. Domain-span processes are discussed in Section 5.2, domain-edge processes in Section 5.3 and the effects of accent in Section 5.4.

There is one other class of observations arising from Experiment 2, compensatory shortening, where domain-edge lengthening within some locus appears to be accompanied by an opposite, though smaller, effect outside the locus. Interpretations of compensatory effects are considered in Section 5.5.

5.2 Domain-span processes

There are three domain-span processes examined in Experiment 2: word-rhyme-span compression, which is supported; word-span compression (polysyllabic shortening) and utterance-span compression, which are not supported. Additional experimental evidence for and against these processes is considered in the following sections.

5.2.1 Polysyllabic shortening

In studies of polysyllabic shortening such as Lehiste (1972) and Port (1981), the measured word is likely to be pitch accented, as discussed in Chapter 3. If so, such results are compatible with the conclusion of Experiment 2 that observed polysyllabic shortening is a result of the variable distribution of accentual lengthening according to word length. In addition, both Lehiste and Port examine series of left-headed words only, such as *speed* . . . *speedy* . . . *speedily*. As word-rhyme compression appears to affect syllable nuclei within the word-rhyme, the results of Lehiste and Port, which show the greatest word-level effect on the nucleus and smaller effects on the onset and coda, are compatible with a combination of word-rhyme compression and the polysyllabic accent effect[1].

Turk & Shattuck-Hufnagel (2000) look for evidence of polysyllabic shortening in accented and unaccented words, using two unaccented conditions: one where emphatic stress precedes the test phrase, and one where the emphatic stress is on the other word in the test phrase. The full set of conditions is exemplified by utterances for the keyword *tuna* (underlined):

Accented Say "DOLPHIN choir" again, don't say "TUNA choir" again.

Accent-on-say SHOUT "tuna choir" again, don't SAY "tuna choir" again.

Accent-in-phrase Say "tuna SCHOOL" again, don't say "tuna CHOIR" again.

The results for left-headed words are largely compatible with those of Experiment 2: thus, in comparisons such as *tune* vs *tuna*, the "syllable centre"[2] shows a word-length effect in all accent conditions, as predicted by word-rhyme compression (and also by the polysyllabic accent effect when the word is accented).

[1] As discussed in Chapter 2, experiments for Swedish (for example: Lindblom & Rapp 1972) and Dutch (Nooteboom 1972) suggest a small word-span compression effect on stressed vowel duration due to syllables preceding the stressed syllable and a large effect due to syllables following the main stress. This is compatible with a combination of the polysyllabic accent effect and word-rhyme compression, if the words are accented. Examination of the materials suggests this to be the case: Lindblom & Rapp, like Port (1981), use words in a fixed frame sentence, and Nooteboom reports stressed vowel duration in isolated words; in both cases, the measured words are highly likely to carry phrasal stress.

[2] Details of the subsyllabic constituents measured by Turk & Shattuck-Hufnagel are given Chapter 3.

Word-initial syllable onset aspiration is significantly longer in *tune* than in *tuna* in the accented condition, which could be due to the polysyllabic accent effect, and also to the attenuation of initial lengthening in polysyllables. The latter effect is suggested in Experiment 2 by the shortening of word-initial syllable onsets in unaccented left-headed disyllables compared with monosyllables (for example, /m/ is shorter in *mason* than in *mace*) and could also be responsible for the observation by Turk & Shattuck-Hufnagel of shortening of stressed syllable onset closure duration in disyllables in the accent-in-phrase condition. No evidence of this effect is observed in the accent-on-say condition, however, possibly influenced by the presence of an accent immediately preceding the measured syllable onset (for example: *. . . don't SAY "tuna choir" again*): Turk & White (1999) show some lengthening in words following accented monosyllables, which could mask any effect of word length on the magnitude of initial lengthening.

The results for the stressed syllable final consonant in left-headed words are in line with those for Experiment 2. The difference in duration of, for example, /n/ in *tune* vs *tuna*, only approaches significance in the accented condition, in line with the polysyllabic accent effect and the assertion that the locus of word-rhyme compression is the syllable nucleus.

Some of the results for right-headed keywords reported by Turk and Shattuck-Hufnagel are less in agreement with those of Experiment 2. The first consonant, however, clearly shows the word-initial lengthening effect, although not as consistently as in Experiment 2: for example, in all three accent conditions either the closure or the aspiration of /k/ is longer in *choir* compared with *acquire*.

According to the polysyllabic accent hypothesis, the syllable centre should show a word-length effect in the accented condition, but not otherwise. This is not what is observed, however: the only significant difference in a By-Subjects analysis in, for example, /waɪ/ between *choir* vs *acquire*, is in the accent-on-say condition. In the other two conditions, the greater duration of /waɪ/ in the monosyllable than in the disyllable is significant only in a By-Items analysis. It may be noted, however, that the syllable nucleus in right-headed keywords in Experiment 2 actually shows a small lengthening effect in the disyllable compared with the monosyllable: for example, /ɛ/ is slightly longer in *commend* than in *mend*. This effect, found in both accented and unaccented keywords, is the only positive correlation found between word-length and subconstituent duration in Experiment 2 and is attributed in Section 5.5 to a compensatory effect prompted by the large word-initial lengthening effect on the preceding segment in the monosyllable.

This may explain the lack of a word-length effect for the syllable centre in accented right-headed keywords in Turk & Shattuck-Hufnagel's study, which show the largest

word-initial lengthening of the syllable onset. The compensatory shortening of the syllable centre following the lengthened onset in *choir* compared with *acquire* may serve to mask the underlying polysyllabic accent effect on the nucleus. The reason for the observation of a word-length effect in right-headed words in the accent-on-say condition is unclear, however: possible explanations are discussed further below.

The results for final consonant duration indicate no significant differences according to word length in right-headed keywords. This is in line with the results of Experiment 2 except for the accented condition, where /ɹ/ should be longer in *choir* than in *acquire*, due to attenuation of accentual lengthening in the disyllable. The word-length effect on the test syllable coda in right-headed accented keywords is relatively small, however: for example, in Experiment 2, the shortening of /z/ in *presuppose* compared with *suppose* when accented is smaller than that found on the onset and nucleus. The reason given in Chapter 4 is that accentual lengthening appears greater at the edges of accented words than at the centre, and thus the polysyllabic accent effect is greatest on segments which have different alignment with word edges in monosyllables, disyllables and trisyllables: /p/ receives a lot of accentual lengthening in *pose*, less in *suppose* and less still in *presuppose*, whereas the word-final consonant remains word-final throughout the sequence, and thus accentual lengthening is attenuated only slightly. The evidence for the distribution of accentual lengthening which may underlie these observations is compared with previous results in Section 5.4 below.

A further contributing factor to the absence of a polysyllabic accent effect on the word-final consonant could be the unusual syllable segmentation used by Turk & Shattuck-Hufnagel: in four out of 11 cases, part of the syllable coda is measured with the syllable centre. Furthermore, the final consonant in the phrase is also antepenultimate in the utterance, being followed only by the word *again*, and thus may be subject to some durational influence of utterance-finality: the actual magnitude of accentual lengthening appears to be slightly, if not significantly, reduced utterance-finally, as found in Experiment 2 and by Cambier-Langeveld (2000); a corollary of reduced accentual lengthening would be a smaller difference in accentual lengthening between monosyllables and disyllables.

Given these factors which may affect final consonant results, the most problematic discrepancy between the results of Turk & Shattuck-Hufnagel and the processes suggested by Experiment 2 is the finding, mentioned above, of a word-length effect on the syllable centre in the unaccented, accent-on-say condition (for example: *. . . don't SAY "tuna choir" again*), and also a significant effect (By-Items only) in the unaccented, accent-in-phrase condition (for example: *. . . don't say "TUNA choir" again*): thus, in both cases /waɪ/ is longer in *choir* than *acquire*. This is not predicted by any of the word-level mechanisms proposed in Chapter 4: word-initial lengthening has a sylla-

ble onset locus; the polysyllabic accent effect only pertains to accented words; word-rhyme compression, although having a syllable nucleus locus, is proportional to the length of the word-rhyme, which is constant in right-headed words with a final primary stressed syllable. One factor which may contribute somewhat to the observed effect is the segmentation used by Turk & Shattuck-Hufnagel: where the syllable contains a complex onset, only the first consonant is measured separately. This is the case for three out of 11 right-headed keywords—*quit* vs *acquit*, *press* vs *oppress*, *choir* vs *acquire*—where the syllable centre contains a consonant that would normally be regarded as part of the onset. As it seems very clear that the onset is subject to lengthening in monosyllabic context, there is likely to be lengthening within the syllable centre in these three tokens. How much effect this has on the magnitude of the observed effect across all the materials is uncertain.

It is possible that the structure of the experimental materials and the placement of accents in Turk & Shattuck-Hufnagel's study may also have some bearing on the outstanding disparity between these findings and those of Experiment 2. Firstly, the test words, like those in Experiment 1, are placed in a metalinguistic context, with the phrase containing these words spoken in something like a citation form, for example (test phrase underlined):

SHOUT "tuna choir" again, don't SAY "<u>tuna choir</u>" again.

It may be that this structure causes the whole phrase to be focused, so that words within the phrase are subject to a certain amount of lengthening even when unaccented. This could account for the evidence of polysyllabic shortening in the "unaccented" conditions, although it is not clear why this evidence should be largely restricted to the stressed syllable centre of right-headed keywords.

Secondly, the pattern of results differs between the two "unaccented" conditions: as Turk & Shattuck-Hufnagel (2000:427) point out, "the magnitude of word-boundary-related effects appears to be tied to the occurrence of a pitch accent nearby". If the effects of accent placement were entirely restricted to the accented word, there should be no difference between the unaccented accent-on-say condition and the unaccented accent-in-phrase condition. As noted in Chapter 2, Turk & White (1999) find a small amount of lengthening on the syllable following an accented monosyllable despite the intervening word boundary; Herment-Dujardin & Hirst (2002) suggest that "words preceding a focused word are usually shorter"[3]. These factors could play a part in Turk & Shattuck-Hufnagel's study; in contrast, in the unaccented condition in Experiment 2, pitch accents are placed some distance from the measured syllables.

[3]The interpretation of durational effects of accent placement beyond the accented word is discussed further in Section 5.4.

This discussion suggests that the results of previous studies regarding polysyllabic shortening are, to a first approximation, in line with the findings of Experiment 2. Most of the differences between Experiment 2 and Turk & Shattuck-Hufnagel (2000) may be related to methodological factors, in particular the phrasing and placement of accent in the materials in the latter study, and possibly the segmentation into subsyllabic constituents used there. If it is correct, then, to conclude that polysyllabic shortening arises as a result of variations in accentual lengthening, it is important to know how the distribution of lengthening varies according to word length. The picture presented in Chapter 4 is compared with the results of the studies by Sluijter (1995), Turk & Sawusch (1997) and Turk & White (1999) in Section 5.4.

5.2.2 Word-rhyme compression

The results of Experiment 2 suggest a word-rhyme-span process, independent of pitch accent, with a syllable nucleus locus. This finding agrees with previous results for left-headed keywords, such as those of Lehiste (1972) and Port (1981), which indicate that the syllable nucleus shows the greatest compression effect due to word length. Similarly, Oller (1973) finds a word-final lengthening effect which appears greater on the syllable nucleus than on the coda. If it is correct to infer that the test words in these previous experiments are accented, than two processes would be present. Firstly, the polysyllabic accent effect , causing all parts of the syllable to be shorter in accented words of more syllables. Secondly, a word-rhyme compression effect, further shortening only the syllable nucleus when it is separated from the end of the word by one or more syllables. The evidence from the current experiment suggests that the polysyllabic accent effect and word-rhyme compression combine sub-additively: the effect of two shortening processes being less than the sum of the two processes acting separately suggests limits to compressibility of the sort proposed by Klatt (1976).

Word-rhyme compression is similar in effect to what Turk & Shattuck-Hufnagel (2000) call "syllable ratio equalisation". As discussed in Chapter 3, this is proposed to account for Abercrombie's (1965) observation that the syllables in *greater* are more similar in duration than those in *Grey to*. Turk & Shattuck-Hufnagel find evidence to support such a process with a syllable nucleus locus: in comparisons such as *tune* vs *tuna*, most of the shortening in the disyllable is manifest on the syllable centre, in all accent conditions. In addition, the central unstressed syllable in comparisons such as *tune acquire* vs *tuna choir* does not manifest durational variation due to word-membership such as would be consistent with an "asymmetrical polysyllabic shortening" process; thus, they argue, if polysyllabic shortening is symmetrical, the greater word-length effect on stressed syllable centres in left-headed keywords must be due to an additional process.

The results of Experiment 2 suggest that Turk & Shattuck-Hufnagel are correct to identify the syllable centre/nucleus as the locus of the effect within the primary stressed syllable; there is little evidence in onset and coda duration of word-rhyme compression. The results of Experiment 2 indicate, however, that the locus extends to other syllables within the word rhyme: for example, /ən/ is shorter in *masonry* than in *mason*, and it is hypothesised that the effect is localised on the nucleus in unstressed syllables as well. The effect on unstressed syllables in Turk & Shattuck-Hufnagel's experiment is difficult to determine, as they may be subject to different durational influences according to the different position-in-word and pitch accent conditions. In comparisons such as *tune acquire* vs *tuna choir*, the central unstressed syllable is either word-initial or word-final, and the main durational influence on this syllable is lengthening due to membership of an accented word, whether preceding or following the primary stressed syllable. In the accent-on-say condition, however, there is no accent within the test phrase and there appears to be either an absence of word-initial and word-final effects, or a balance between the two, as there is no difference in the duration of, for example, /ə/ in *tuna* vs *acquire*. Word-initial lengthening is well-established, as discussed in Section 5.3, but the locus appears to the syllable onset, and in Turk & Shattuck-Hufnagel's materials there is only one central syllable out of 11 which contains an onset. As the existence of a durational effect on absolute word-initial vowels in not certain, the balance between different processes on the central unstressed vowel cannot be determined[4]: if there is no effect of absolute-word-initial position on vowels, however, then there appears to be no evidence for a word-final lengthening effect. The word-rhyme compression interpretation may be still available, however: for the unstressed syllable, a disyllabic word-rhyme is the shortest possible, thus a domain-span effect might only exert a compression in a longer word-rhyme. In word-initial position, the unstressed syllable is not dominated by a word-rhyme and would likewise not be subject to word-rhyme compression. This absence of a compression effect in both cases could explain the lack of durational difference in, for example, /ə/ in *tuna* vs *acquire*.

It is argued in Chapter 3 that the syllable ratio equalisation mechanism is unnecessary, because a combination of domain-span processes could account for the results equally adequately without requiring the postulation of a different *type* of process. Experiment 2 does not, however, provide support for the existence of any suprasyllabic domain-span process other than word-rhyme compression. Thus, the argument put forward in Chapter 3 against syllable ratio equalisation on the grounds of parsimony is not valid here, because both processes appear unique of their kind; that is, both

[4] A word-initial vowel may be glottalised, which is likely to lengthen its total duration. Studies such as Dilley *et al.* (1996) indicate that glottalisation is more likely at higher-level prosodic phrase boundaries and when the word is accented.

word-rhyme compression and syllable ratio equalisation are processes predicated to explain results within a single domain.

Theoretical and empirical arguments are available for maintaining the preference for the domain-span interpretation. Firstly, the greater shortening of the syllable nucleus for left-headed keywords which Turk & Shattuck-Hufnagel observe in monosyllables vs disyllables is also observed in disyllables vs trisyllables in Experiment 2: thus, /eɪ/ is shorter in *masonry* than in *mason*. It is not clear how syllable ratio equalisation would accommodate this result. Secondly, syllable ratio equalisation appears to belong more naturally to the sphere of rhythmical processes, defined in Chapter 1 as those arising from the distribution of lexical stress; as indicated in Chapter 2, evidence suggests that the primary rhythmical process is stress-adjacent lengthening, which does not respect the boundaries of syntactic or prosodic constituents and appears to arise from a separate subsystem in the representation of speech timing. The effect on stressed syllable nucleus duration under discussion here appears, in contrast, to be dependent on word structure.

An account in terms of existing processes, for which independent evidence exists at other levels of linguistic structure, would be preferable to either word-rhyme compression or syllable ratio equalisation. The interpretation of word-rhyme compression as word-final lengthening is examined further in Section 5.3.2.

5.2.3 Utterance-span compression

Jones (1942–43) claims that domain-span compression processes may be observed in sentences; Lehiste (1974; cited in Klatt 1976) and Rakerd *et al.* (1987) find experimental evidence to support this. The results of Experiment 2, however, are line with those of Gaitenby (1965), who finds little effect of sentence length that cannot be better explained as a domain-edge process. Segments near the utterance-final boundary are subject to lengthening, and thus will be shorter if utterance size is increased by placing additional words following the measured segments. For example, the phrase *for tomorrow* is measured in:

1. Why don't you get tickets for tomorrow?

2. Why don't you get tickets for tomorrow night's programme?

and found to be longer in Sentence 1 than in Sentence 2. The results of Experiment 2 suggest that the difference is likely to be localised within the word-rhyme /mɒɹəʊ/ and progressive within this locus.

In addition, as suggested by Gee & Grosjean (1983), longer utterances tend to comprise more constituent phrases than shorter utterances. Where the alignment of a

measured subconstituent with respect to phrase boundaries is different in longer and shorter utterances, durational consequences will be observed. For example, in:

1. The frog leapt from the lily pad.

2. Bill the happy bullfrog leapt from the lily pad.

the durational of /l/ in *leapt* may be greater in Sentence 2, where it is more likely to be preceded by a phrase boundary than in Sentence 1. Similarly, the duration of /ɒg/ in *frog* may be greater in Sentence 2 than in Sentence 1, although, as pointed out in Chapter 4, the evidence for phrase-final lengthening below the intonational phrase remains inconclusive.

Such observations are in the opposite direction to those suggested by Jones, Lehiste and Rakerd *et al.*, who predict shortening in longer utterances. In addition to the absence of utterance-final lengthening, as illustrated in the Gaitenby example above, there are two reasons why an inverse relationship between utterance size and subconstituent duration might be observed. Firstly, as discussed in Chapter 2, Gee & Grosjean suggest that there is a tendency for the phrases into which an utterance is divided to be of similar size. In some cases, this could mean that words are adjacent to a phrase boundary in a shorter sentence, but not in a longer sentence, the boundary being placed elsewhere for reasons of balance between subconstituents. Secondly, in certain time-restricted circumstances, there is likely be an inverse correlation between the size of the utterance and the rate at which it is spoken. In an experimental task, for example, where speakers are required to read successive sentences presented at a fixed rate, it may be necessary to read longer sentences more quickly to finish them within the time available. Such an effect may also be observed in non-experimental speech tasks when time is restricted: for example, a radio continuity announcer with a short time between programmes will talk more quickly when the content of links is longer. In most normal situations, however, speech is not restricted to a fixed time frame, although emotional factors such as a feeling of pressure to complete one's turn could cause an increase in speech rate in some circumstances.

Given the lack of evidence for an utterance-span effect, it may be asked whether other constituents manifest domain-span compression. The evidence for word-span compression suggests this is an indirect effect related to accent. Word-rhyme compression is supported but may be interpreted as a word-final effect. Furthermore, the word-rhyme has not been proposed as a constituent of prosodic hierarchies, and violates the constraint of exhaustivity—as discussed in Chapter 2—required by some accounts. The possibility that constituents between the word and the utterance, such as various types of prosodic phrase, could be domains of compression processes has not been examined. In Experiment 2, the intonational phrase is, in most cases, co-extensive

with the utterance, so it seems unlikely that there exists an intonational-phrase-span compression process. The possibility remains that other levels of the prosodic hierarchy, such as phonological phrases, may manifest an inverse relationship between length and subconstituent duration, but the most significant consequences of variations in phrasing appear to be localised and associated with boundaries.

5.3 Domain-edge processes

There is evidence in Experiment 2 of domain-edge lengthening word-initially, phrase-initially and utterance-finally; there is also some evidence of an utterance-initial shortening effect. The nature of these processes and the additional experimental evidence for them are discussed in the following sections. As noted above, word-rhyme compression may be interpreted as a word-final lengthening process; arguments for this interpretation are presented below.

5.3.1 Initial lengthening

Experiment 2 suggests two levels of initial lengthening below the level of the intonational phrase, word-initial and (phonological) phrase-initial, and also suggests that there may be an absence of hierarchical lengthening effects utterance-initially.

Word-initial lengthening

Word-initial lengthening is a large effect, with a syllable onset locus: this supports findings, discussed in Chapter 2, of Oller (1973) and Cooper (1991), who find lengthening of the word-initial syllable onset, and of Fougeron & Keating (1997), Turk & Shattuck-Hufnagel (2000) and Byrd (2000) who suggest that lengthening does not extend beyond the word-initial syllable onset. The greater magnitude of lengthening in accented words is probably due to the additional influence of the polysyllabic accent effect: the stressed syllable onset is word-initial in monosyllables, such as *mend*, and word-medial in disyllables and trisyllables, such as *commend* and *recommend*; thus, both word length and position-in-word should cause shortening in polysyllables compared with monosyllables when the word is accented. Confirmation of this would require comparison of syllable onsets in word-initial and word-medial position in accented and unaccented words of equal length: for example, /d/ in *debtor* vs *cadet* would be expected to show no interaction between word-initial lengthening and pitch accent[5].

[5]Even in this comparison, there may be a slightly larger word-initial lengthening effect in accented words: /d/ is likely to receive greater accentual lengthening in *debtor* than in *cadet*, as the magnitude of lengthening appears to be greatest at the edges of accented words.

Where the stressed syllable onset is a voiceless stop, the effect of position-in-word appears to be similar both for closure duration and for aspiration duration in accented and unaccented syllables; in contrast, Oller (1973) and Cooper (1991) indicate that word-initial lengthening of closure duration is greater in unaccented syllables and that aspiration duration is longer word-medially than word-initially in accented syllables. Those studies do not conflate word length and position-in-word because they examine the effect on onset duration of position in words of fixed length; in Experiment 2, however, possible word-medial lengthening of aspiration could be masked by the polysyllabic accent effect: thus, the aspiration of /p/ is longer in *pose* than in *suppose*, at least partly due to the greater accentual lengthening it receives in the monosyllable[6].

There are two features associated with word-initial lengthening which have not previously been identified. One is the possible compensatory shortening of the following vowel, as discussed in Section 5.5. The other is the attenuation of word-initial lengthening in polysyllables: onset duration is shorter in monosyllables such as *mace* than in left-headed disyllables and trisyllables such as *mason* and *masonry*, even in unaccented words, where no effect of word length is predicted on the syllable onset. This shortening effect appears to be a binary distinction, as there is no durational difference in test syllable onset duration between unaccented left-headed disyllables and trisyllables. Examination of the data of Turk & Shattuck-Hufnagel (2000) provides some support for this finding, as discussed in Section 5.2.1 above.

There is evidence in Experiment 2 of word-initial lengthening in unstressed syllables, as found by Oller, Cooper and Fougeron & Keating: here the effect is found to be small in unaccented words. This resembles the pattern found in Experiment 1 for stressed syllables: in both cases, subsyllabic constituents are not measured and it may be that initial lengthening of the onset is masked by compensatory shortening of the nucleus. In the accented condition, lengthening due to word-initial position is reinforced by the polysyllabic accent effect, as outlined above.

Phrase-initial lengthening

The evidence for phrase-initial lengthening in Experiment 2 is that word-initial stressed syllable onsets have greater mean duration in utterance-medial context than in near-utterance-initial context: apparently the measured onset is more likely to be preceded by a phrase boundary in utterance-medial position, and where there is such a bound-

[6] An alternative interpretation of the results of Oller (1973) and Cooper (1991) is that word-initial lengthening of closure and aspiration is greater in *unstressed* syllables. For example, Cooper finds that aspiration duration of /k/ is greater in *ki*ˈ*kik* than in ˈ*kikik*, whereas the effect of position is reversed in stressed syllables: thus, the aspiration of /k/ is shorter in ˈ*kikik* than in *ki*ˈ*kik*. In Experiment 2, only stressed syllables are examined, and aspiration duration is longer word-initially in both accented and unaccented words. As pointed out above, this lengthening in accented words is also predicted by the polysyllabic accent effect.

ary, this is associated with lengthening of the following syllable onset: for example, /m/ is longer in

B.3 JONATHAN saw Jessica **mend** it AGAIN.

than in

D.3 Will you **mend** it AGAIN for me please.

The type of phrase must be between the word level and the intonational phrase level, probably what is commonly called the phonological phrase. This result supports that of Fougeron & Keating (1997), who find word-initial and phonological-phrase-initial lengthening of unstressed syllable onsets, as well as intonational-phrase-initial lengthening. In contrast, Wightman *et al.* (1992) do not find a correlation between prosodic boundary strength and syllable onset duration: possible confounding factors in their experiment are discussed in Chapter 4.

Utterance-initial effects

There is evidence in Experiment 2 of an absence of hierarchical lengthening utterance-initially, so that syllable onsets have comparable duration to those found word-medially. Fourakis & Monahan find that the syllable /mə/ is 30 % shorter utterance-initially than when preceded by another syllable; they do not, however, report subsyllabic durations, so the locus of the effect cannot be determined precisely. Fougeron & Keating find a similar effect in reiterant speech with a precise locus: the syllable onset /n/ is shorter for two out of three speakers utterance-initially than utterance-medially; for one speaker, for example, /n/ is 21% shorter utterance-initially. Both of those studies use nasal onset consonants in unstressed syllables; in Experiment 2 the utterance-initial shortening effect is found for the nasal /m/ and the fricative /s/ in stressed syllable onsets. The interpretation of this effect given in Chapter 4 is that the utterance boundary is not signalled durationally because the end of the foregoing silence provides a sufficient cue.

Stressed syllable onsets containing stops or affricates do not demonstrate utterance-initial shortening, however: closure duration cannot be measured acoustically in utterance-initial position and the duration of aspiration or frication which follows the stop release is longer utterance-initially in unaccented words, and shows no effect of position in accented words. The reason for this is not clear. It is unlikely to be because aspiration/frication should be regarded as part of the nucleus, because these phases show the same pattern of word-initial lengthening as the preceding closure duration. As suggested in Chapter 4, it may reflect a more forceful—and thus longer—stop release where this is initiating phonation; the lack of effect in accented syllables may be attributable to the fact that they have more forceful articulation in any position.

Articulatory data could indicate the pattern of consonant closure duration in utterance-initial and utterance-medial position, and it may be that the whole onset gesture shows the same durational pattern seen for *main*, *mend* and *send*, with apparent absence of any hierarchical lengthening effect; alternatively, the whole gesture for /m/ or /s/ could show lengthening utterance-initially. Such findings would run counter to the idea of degrees of hierarchical lengthening as cues for listeners, however: there is no point in varying the duration of a gesture with no acoustic correlate[7].

More research is required using a range of onset phonemes to determine the relative contributions of prosodic hierarchical structure and of constraints upon articulation due to initiation of phonation. The evidence presented here suggests that for some onset consonants at least, the utterance-initial shortening effect previously noted by Fourakis & Monahan (1988) and Fougeron & Keating (1997) may be the result of degrees of domain-initial lengthening associated with levels of a prosodic hierarchy and the special status of the utterance-edge as a boundary that does not require cues other than the fact of speech being initiated.

Different results may be obtained in a long stretch of continuous speech, containing a number of phonological utterances. Here, the breaks in speech between utterances may not be greater than planned mid-utterance pauses at, for example, intonational phrase boundaries. In this case, the utterance should manifest initial lengthening relative to lower-level phrases, because the primary cue to the utterance-initial boundary in isolated sentences, the breaking of hitherto ongoing silence, is not present in continuous speech. The utterance boundary may, of course, be marked by pre-boundary lengthening, but as discussed in the following section, the magnitude of this effect may be no greater utterance-finally than intonational-phrase-finally.

5.3.2 Final lengthening

Utterance-final lengthening

The results of Experiment 2 indicate a number of facts about utterance-final lengthening:

- The locus of lengthening is the word rhyme, although not all subconstituents are affected.
- Lengthening is progressive within the locus.

[7] It may be noted that Fougeron & Keating (1997) find that the articulatory strengthening (in terms of the degree of maximum linguopalatal contact for /n/) of syllable onsets at higher domain edges does not show the same pattern as for duration, where two of the three speakers show utterance-initial shortening relative to lower domain edges. For linguopalatal contact, the maximum at the domain edge is at least as great utterance-initially as at lower levels.

- There is no significant interaction between final lengthening and accentual lengthening.

The question of the number of levels of final lengthening remains unresolved, however.

Researchers such as Oller (1973) and Campbell & Isard (1991) indicate that lengthening in absolute-utterance-final position is localised on the syllable nucleus and syllable coda. Studies such as Nakatani *et al.* (1981) and Turk (1999) find that the locus of *phrase-final* lengthening may extend to the penultimate syllable where the phrase-final syllable is unstressed. Cambier-Langeveld (2000) finds a similar locus for utterance-final lengthening in English, an expected result given that the locus of utterance-final lengthening ought to be at least as extensive as that for phrase-final lengthening. Experiment 2 supports the finding that the locus of lengthening in an absolute-utterance-final stressed syllable is the syllable rhyme; it further shows that when the stressed syllable is in utterance-penultimate position and followed by an unstressed syllable within the word (for example, ... *mason*||) the lengthening on the stressed syllable is less than absolute-finally, and restricted to the syllable coda[8], and the following unstressed syllable undergoes a large amount of lengthening. Furthermore, a small amount of lengthening is found on the stressed syllable coda in antepenultimate position, when followed by two unstressed syllables within the word (for example, ... *masonry*||) and both the unstressed syllables show lengthening, the greatest effect being on the syllable in absolute-final position.

The distribution of utterance-final lengthening within unstressed syllables was not measured directly, although from the differences between materials it may be inferred that lengthening is localised on the syllable coda in the penultimate unstressed syllable: thus, all the words that have a medial syllable with a coda consonant (*masonry*, *tendency*, *captaincy*) show an utterance-penultimate lengthening effect on that syllable; the other unstressed syllables are open and do not show utterance-penultimate lengthening except for /tə/ in *spectacle*. It might be assumed that lengthening in absolute-utterance-final unstressed syllables is localised on the syllable rhyme, as for stressed syllables. Subsyllabic measurements from a range of unstressed syllables would be required to resolve this issue.

Experiment 2 also suggests there may be some lengthening of the stressed syllable coda when followed by a word boundary and one or two unstressed syllables before the utterance boundary (for example ... *mace up*|| and ... *mace again*||). More research needs to be done to determine if this effect is consistent and is related to utterance

[8] As noted in Chapter 4, the stressed syllable coda /s/ in *mason* could also be regarded as ambisyllabic or as the onset of the following test syllable. The decision to treat it as a coda consonant in Experiment 2 allows consistency in interpretation of the results: final lengthening of syllable onsets is not widely reported.

position, rather than to possible confounds such as stress-adjacent lengthening and segmental effects: these may arise because the phonetic and stress environment of the test syllable is not always matched between utterance-medial and utterance-final contexts. Given that utterance-final function words are not reduced, however, it may be impossible fully to distinguish the potential durational influences in this case. If utterance-final lengthening were consistently found across word boundaries, as just discussed, then the identification of the locus as the word-rhyme would have to be altered to a constituent headed by a primary lexical stress and continuing to the start of the next primary lexical stress, regardless of word boundaries: as discussed in Chapter 2, this corresponds to one interpretation of the Abercrombian foot.

In Experiment 2, the duration of syllables preceding the final stressed syllable is not measured; however, where the stressed syllable is in absolute-final-position, Turk (1999) finds no evidence of phrase-final lengthening on the unstressed syllable that precedes it. This and other studies, such as Oller (1973), strongly suggest that the locus of final lengthening begins with the final stressed syllable. The word-rhyme, as defined in Chapter 3, is the constituent which best describes the locus of utterance-final lengthening; as noted above, not all subconstituents of the word-rhyme are affected by lengthening.

The distribution of lengthening on syllables within the word-rhyme clearly tends to be progressive. Cambier-Langeveld (2000) finds that in words such as *Joseph* and *Macy*, absolute-final unstressed syllables show greater lengthening than the preceding stressed syllables. Similar trends are also apparent within syllables: for example, for intonational-phrase-final lengthening, Turk (1999) reports a progressive lengthening effect within the final syllable rhyme, as do others, such as Berkovits (1994) for Hebrew. In Experiment 2, lengthening is shown to be progressive both within the absolute-final syllable rhyme and within the word-rhyme where the final stressed syllable is in utterance-penultimate or utterance-antepenultimate position. As Oller (1973) indicates, however, there may be variations from this trend due to segmental differences in expandability: for example, final voiced stops may manifest less lengthening than other coda consonants.

Price *et al.* (1991) suggest that final lengthening and accentual lengthening combine subadditively. Cambier-Langeveld (2000) finds this effect for Dutch, but only slight evidence of such an interaction for English: as shown in Table 2.1 in Chapter 2, both syllables in disyllabic words such as *Joseph* and *Macy* show a greater proportion of final lengthening in unaccented keywords and the initial stressed syllable also shows a greater absolute magnitude of lengthening in unaccented words, but the interaction between accent and utterance position is not statistically significant for either syllable. The result of Experiment 2 is quite similar to that reported by Cambier-Langeveld:

there is no significant interaction between pitch accent and utterance position, but there is a tendency towards a slightly greater effect of utterance position in the comparison between unaccented words.

The lack of statistical support indicates that this is not a major effect, such as Cambier-Langeveld finds for Dutch, but the consistency with which is observed in Experiment 2 and by Cambier-Langeveld suggests that it may be genuine. The observation is probably explicable as a ceiling effect: if segments are lengthened by a large amount due to accent, there may be less scope for lengthening due to utterance-final position. This is supported by the evidence from Dutch. Cambier-Langeveld argues that Dutch has less variability in vowel duration than English, and thus the combination of two lengthening effects is greatly sub-additive. The wider range of possible durations for English mean that the durational ceiling is only reached in extreme cases and there is some evidence that there is no ceiling effect phrase-finally. In Experiment 1, the accentual lengthening on the phrase-final syllable in phrases such as *thank fulfil* and *thankful Phil* is greater in absolute magnitude and proportionally comparable to that found on phrase-initial syllables, with the caveat that the syllables compared between the two positions are segmentally different. Similarly, Cummins (1999), looking at a range of speech rates, finds that accentual lengthening and phrase-final lengthening combine approximately additively for most rates; at the fastest rate, there is little evidence of either effect, a fact which may reflect a general change in the nature of the task under unusual conditions rather than segmental limitations on duration as such. Thus, the subadditivity of final lengthening and accentual lengthening may be a particular feature of utterance-final lengthening, which would suggest that it has greater magnitude in English than phrase-final lengthening.

It is not demonstrated that utterance-final lengthening is distinct from intonational-phrase-final lengthening, however. Wightman *et al.* (1992) report no significant difference in the magnitude of final lengthening of the final syllable rhyme between the intonational phrase and the utterance. It is possible that the locus of lengthening may be more extensive utterance-finally; however, Cambier-Langeveld (2000) finds a similar locus for intonational-phrase-final and utterance-final lengthening in Dutch.

There is a lack of evidence in Experiment 2 for phrase-final lengthening below the intonational phrase. There are two alternative interpretations of this observation: firstly, the left-headed keywords in the experimental materials are never followed by phrase boundaries, or so rarely as to have no effect on the mean duration of the pre-boundary nucleus and coda; secondly, phrase boundaries are present following left-headed keywords—as there appear to be preceding right-headed keywords in some cases—but these boundaries do not have durational consequences for the preboundary word. The latter interpretation contradicts studies such as Wight-

man *et al.* (1992), discussed in Chapter 4, that find evidence of a number of levels of phrasing distinguished by the magnitude of final lengthening; however, Cambier-Langeveld (2000) finds no durational difference in Dutch between word-final syllables and phonological-phrase-final syllables.

Word-final lengthening

One reason given in Chapter 4 for not favouring the interpretation of word-rhyme compression as a domain-final effect is that the nucleus but not the coda is affected: previous studies suggest that domain-final lengthening is progressive—and Experiment 2 finds progressive lengthening utterance-finally—thus at least as much domain-final lengthening would be expected on the coda as on the nucleus. The results for utterance-final lengthening indicate, however, that final lengthening need not be continuous within the locus, but may be localised on discrete subconstituents. For example, the utterance-antepenultimate stressed syllable coda is lengthened, but it is likely that not all subconstituents of the following unstressed syllable undergo lengthening. If the locus of utterance-final lengthening is discrete—affecting certain subconstituents of the word-rhyme—then word-rhyme compression, which affects a different set of subconstituents of the word-rhyme, may also be interpretable as a final lengthening effect.

The strong theoretical reason for favouring the word-final interpretation is that the results of Experiment 2 do not support either word-span or utterance-span compression, so a reinterpretation of word-rhyme compression as a domain-final process—affecting only the nuclei in a word-rhyme locus—would eliminate one type of durational process altogether. This is preferable in theoretical terms to proposing the existence of domain-span compression processes to explain only one set of observations.

Against this domain-final interpretation is the fact that the magnitude of the word-rhyme compression effect may be greater between disyllables and trisyllables than between monosyllables and disyllables: for example, in unaccented words, where there is no influence of the polysyllabic accent effect, the /eɪ/ of /meɪs/ is shortened by 3 ms (4%) between *mace* and *mason* and by 9 ms (12%) between *mason* and *masonry*. The largest difference in a domain-final effect might be expected to be between absolute-final and penultimate position, as is seen for utterance-final lengthening; however, it could be argued that the greatest domain-span compression effect might also be expected between monosyllabic and disyllabic contexts, so the data are not conclusive on this point.

As discussed in Chapter 2, Oller (1973) finds evidence for what he identifies as phrase-final lengthening on the syllable nucleus of the final syllable in reiterant words.

He intends a syntactic definition of "phrase", but the noun phrases containing the measured syllables and the carrier sentences themselves are both rather short (for example, *The bababab is on the table*) and so a major prosodic boundary may be unlikely in these circumstances. In this case, the finding that the durational effect of word position is localised on the syllable nucleus may be seen as support for the results found in Experiment 2, either as word-rhyme compression or word-final lengthening.

As noted above, the word-final interpretation is preferable theoretically because it does not require the postulation of another type of process. It would be desirable to have an empirically-testable difference in the predictions of the two processes, but the effects of position-in-word and word-rhyme length are necessarily confounded for stressed syllables. For an unstressed syllable, however, it is possible to vary the length of the word-rhyme whilst maintaining the alignment of the measured syllable with the word boundary; similarly, its position with respect to the word boundary can be altered whilst the effects of word-rhyme length are kept constant. These possibilities for experimentally distinguishing the two hypotheses are described in Chapter 6.

5.4 Pitch accent

Experiment 2 provides strong evidence that the locus of accentual lengthening is the word, as suggested by Sluijter (1995) and Turk & White (1999); furthermore, the evidence from Experiment 2 suggest that lengthening is greatest at word edges, and that the variation in the distribution of lengthening between monosyllables, disyllables and trisyllables is responsible for previously-observed polysyllabic shortening. This is the polysyllabic accent effect, as defined in Chapter 4. The distribution of accentual lengthening found in Experiment 2 is here compared with that observed in previous studies, and possible reasons for the differences are discussed.

5.4.1 Accentual lengthening in stressed syllables

Turk & Sawusch (1997) report the durational effect of accent on the constituents of monosyllabic words. Their results are shown in Table 5.1: onset and coda durations are estimated from their graphical data. The mean durations for onset, nucleus and coda from Experiment 2 are reported for comparison: these are the means from the data-set used in Figure 4.12 in Chapter 4, pooled between left-headed and right-headed keywords.

In both data-sets shown in Table 5.1, the onset shows the largest proportional effect and the nucleus shows a somewhat smaller proportional effect[9]. The most notable

[9]The largest data-set available for the same Experiment 2 keywords as used in Table 5.1 includes all the monosyllables in Series B, the fixed word-length and variable utterance-length condition. In that

	Onset		Nucleus		Coda	
Experiment 2	26 ms	27%	16 ms	17%	19 ms	23%
Turk & Sawusch (1997)	34 ms	34 %	43 ms	21%	10 ms	12 %

Table 5.1: Comparison of accentual lengthening in subsyllabic constituents of monosyllables. Mean lengthening is shown on the left in each cell; the proportion of lengthening compared with the unaccented duration is on the right. The Experiment 2 data are from Series C: all keywords except *cap*, *dog*, *part*, *speck* and *port* are included.

difference between two data-sets is that the effect on the coda is rather less in Turk & Sawusch's data. This cannot be attributed to variation in the expandability of segments, because the same phonemes are used in the onset and coda measurements: Turk & Sawusch use phrases such as *bee farm* and *beef arm* and measure the vowel in the first word and the central consonant, word-initially and word-finally. The accent is always within the phrase, either on the first word or the second word, and it is possible that the presence of an accent on an adjacent word could cause some lengthening in the unaccented condition, thereby reducing the apparent accentual lengthening effect. This seems more likely to occur in onset consonants, however: Turk & White (1999) demonstrate that some lengthening may spread rightwards across a word boundary following an accented monosyllable but not leftwards. In Turk & Sawusch's materials, /f/ could be lengthened in *BEE farm*, for example, in which case the magnitude of the lengthening in *bee FARM* would be underestimated. It seems much less likely that /f/ would receive any lengthening in *beef ARM*, however, so the reason for the lower estimate of coda accentual lengthening in Turk & Sawusch remains unclear.

The pattern of stressed syllable accentual lengthening that emerges from consideration of the results of the two experiments together is that: firstly, all constituents show significant lengthening; secondly, the onset usually shows the greatest proportional effect; thirdly, the relative magnitude of lengthening in nucleus and coda is variable.

Turk & Sawusch only report stressed syllable accentual lengthening for monosyllables. As described in Chapter 4, Experiment 2 shows that accentual lengthening in the stressed syllable is attenuated in disyllables and trisyllables, with the most marked reduction being in the onset for right-headed keywords—*port*, *report*, *misreport*—and the coda for left-headed keywords—*fish*, *fissure*, *fisherman*. It appears that, in general, accentual lengthening is greater on constituents close to word-initial or word-final boundaries than on word-medial constituents.

data-set, the mean lengthening is are slightly different. In particular, the nucleus effect is slightly larger and the coda effect is slightly smaller than in Table 5.1: onset 27 ms, 28%; nucleus 18 ms, 20%; coda 17 ms, 21%. As the same keywords are involved in both comparisons, this is apparently a result of random variation.

5.4.2 Accentual lengthening in unstressed syllables

Table 5.2 compares the accentual lengthening found on unstressed syllables in disyllables in Experiment 2 with the results of Sluijter (1995) and Turk & White (1999). In Experiment 2, there is more accentual lengthening on word-initial unstressed syllables, such as /kə/ in *commend*, than on word-final unstressed syllables, such as /ən/ in *mason*, and the effect only attains significance for word-initial syllables[10]. The results of Turk & White and Sluijter suggest that the effect on word-final syllables in Experiment 2 would be significant with more data, but the reasons for the difference in magnitude of the word-initial and word-final effects is not clear.

	Word-initial		Word-final	
Experiment 2	18 ms	15%	10 ms	10 %
Sluijter (1995)	13 ms	9%	38 ms	16 %
Turk & White (1999)	8 ms	5%	21 ms	13%

Table 5.2: Comparison of accentual lengthening in unstressed syllables in disyllables. Mean lengthening is shown on the left in each cell; the proportion of lengthening compared with the unaccented condition is on the right. The Experiment 2 data are from all Series C keywords.

In both previous experiments, the measured syllables are in words spoken in metalinguistic context, for example:

Turk & White Say "THANKFUL Phil", don't say "SHAMELESS Phil".

Sluijter Please produce COMPACT for him again.

where measured unstressed syllables are underlined. In Turk & White's materials, the emphasis in the target word is explicitly contrastive; in Sluijter's materials, it is likely to be contrastive given that the target word is the only difference between successive sentences. It may be that the different distribution of accentual lengthening within the word found in Experiment 2 reflects a difference in realisation between contrastive stress and normal phrasal stress. Certainly, the smaller and less reliable accentual lengthening effect observed in word-final syllables in Experiment 2, compared with the previous studies, could reflect a lesser degree of phrasal stress. The results for word-initial syllables, however, do not correspond with the idea of contrastive stress as a simple amplification of non-contrastive accentual lengthening: there is more lengthening in the non-contrastive case in Experiment 2 than in the contrastive case in

[10]The right-headed keywords—listed in Chapter 4—may suggest the possibility that they could be realised differently in accented and unaccented words, in particular, that the first syllable may be spoken with a full vowel. Such variation was not observed in recordings, however.

Turk & White (1999). Selkirk (2002) suggests that are differences in the prosodic properties of contrastive and presentational focus[11]: in particular, she identifies different types of pitch accent that are typically associated with the two types of focus; it may also be that they manifest different patterns of accentual lengthening.

At least three other factors may affect these differences. Firstly, there may be dialectal differences in accentual lengthening distribution: Turk & White, for example, use Scottish English speakers, who show a similar pattern of accentual lengthening to the American English speakers used by Turk & Sawusch (1997), whereas Experiment 2 uses speakers from northern and southern England. Secondly, there may be segmental differences in expandability, both between the materials in the different studies and between the word-initial and word-final syllables in Experiment 2[12]. Thirdly, the right-headed keywords in Turk & White's study are placed phrase-finally in the carrier sentence (for example: *SAY "thank fulfil", don't SHOUT "thank fulfil"*): as discussed in Section 5.2.1, there is some evidence of a slight attenuation of accentual lengthening utterance-finally. Although there does not appear to be an attenuation of accentual lengthening for the phrase-final stressed syllables, such as /fɪl/ in *thank fulfil*, these tokens would have to be recorded phrase-medially to ensure that there is no attenuation of accentual lengthening in a phrase-final word on syllables such as /fʊl/ in *thank fulfil*.

Table 5.3 compares the accentual lengthening found on unaccented syllables in left-headed trisyllabic words in Experiment 2 with the results of Turk & White (1999). In both experiments, there is less accentual lengthening on word-medial unstressed syllables, such as /ən/ in *masonry*, than on word-final unstressed syllables, such as /ɪ/ in *masonry*. In Experiment 2, however, the effects do attain not significance.

	Word-medial		Word-final	
Experiment 2	4 ms	6%	14 ms	9%
Turk & White (1999)	12 ms	11%	22 ms	14%

Table 5.3: Comparison of accentual lengthening in unstressed syllables in left-headed trisyllables. Mean lengthening is shown on the left in each cell; the proportion of lengthening compared with the unaccented condition is on the right. The Experiment 2 data are from all left-headed keywords in Series C.

[11] What Selkirk calls "presentational" focus may be interpreted as non-contrastive phrasal stress.

[12] The magnitude of accentual lengthening of both unstressed syllables in the left-headed keywords may be underestimated slightly, as noted in Table E.3 in Appendix E. For the unstressed syllable immediately following the test syllable, the test-syllable-final stops in *spec.tre/spec.ta.cle* and *cap.tain/cap.tain.cy* are not always released, thus the closure durations of the unstressed syllable onset stops are not reliably measurable and so the syllables are measured from the stop release. For the word-final unstressed syllables in trisyllables, the final stops are not always released in *dogmatist* and *partnership* and so the syllable is measured up to the onset of stop closure in these cases.

As just discussed with regard to disyllables, the smaller effect in Experiment 2 could be because the phrasal stress is not contrastive. However, the effects of accent in right-headed trisyllables, not reported previously in English, are large and reliable word-initially: syllables such as /ɹɛ/ in *recommend*, for example, show 21 ms (15%) accentual lengthening. Word-medial syllables, such as /kə/ in *recommend*, show 6 ms (5%) lengthening, comparable with the effect seen for word-medial syllables in left-headed trisyllables.

There may be a particular reason for the strong effect seen on the word-initial syllable in right-headed trisyllables: in most cases, these syllables contain full vowels, and may receive secondary lexical stress. In some cases, as noted in Section 4.3.3, speakers realise these words with the primary stress on the initial syllable; although such cases are discarded from the analysis where detected, it may be that the secondary stressed syllables manifest more accentual lengthening than unstressed syllables. Against this hypothesis is the fact that Turk & White (1999) find that the pattern of accentual lengthening in disyllables containing a secondary stress, such as *kneecap* and *capsize*, is very similar to that found in disyllables containing only one stress, such as *thankful* and *fulfil*.

The pattern of accentual lengthening within the word in Experiment 2 may be seen as mirroring the pattern within the primary stressed syllable in both Experiment 2 and Turk & Sawusch (1997): in most cases, the onset shows the greater degree of lengthening within the primary stressed syllable; similarly, within the word, initial unstressed syllables showing more lengthening than final unstressed syllables.

A picture of accentual lengthening emerges thus: the locus is the whole lexical word, and the greatest lengthening effects are to be found word-initially and word-finally. This reflects the bimodal accent hypothesis presented in Chapter 4—that the locus is the primary stressed syllable and the word-final syllable, and syllables adjacent to the locus also manifest small lengthening effects—but extends it to word-initial syllables also. If this picture is accurate, then the relatively small word-initial effects found in Sluijter (1995) and particularly in Turk & White (1999) need to be accounted for. A number of factors may influence the observed difference: variation in distribution of accentual lengthening between contrastive and non-contrastive accent; dialectal differences in the distribution of accentual lengthening; variation within the locus due to segmental differences; and differences in the pattern of accentual lengthening phrase-finally and phrase-medially.

Accentual lengthening beyond the word

It is not clear how the finding reported in Turk & White (1999) of a small amount of lengthening on the word following an accented monosyllable should be accommo-

dated within the view of the word as the locus of accentual lengthening. Turk & White show, for example, that the duration of /fʊl/ is about 4% greater in *THANK fulfil* than in *thank fulfil*. This effect is much smaller than most of the accentual lengthening effects observed within the word: for example, /fʊl/ is about 13% longer in *THANKful Phil* than in *thankful Phil*. There is no evidence of a similar effect in words preceding an accented monosyllable: for example, /fʊl/ is not significantly longer in *thankful PHIL* than in *thankful Phil*.

Turk & White suggest that the "residual" lengthening in an unaccented word following an accented monosyllable indicates that word boundaries attenuate lengthening, rather than block it altogether. They further suggest that the effect is not observed in a word preceding an accented monosyllable because the left edge of the accented syllable also attenuates lengthening: the combined effects of the syllable boundary and the word boundary effectively eliminate any lengthening on the preceding word. The results discussed above for Experiment 2 suggest, however, that accentual lengthening is not attenuated at the left edge of the accented syllable, at least for non-contrastive pitch accent.

The existence of residual lengthening beyond the boundaries of the accented words needs further investigation, as the effect has only been observed following accented monosyllables in metalinguistic context. If confirmed—for example, by measuring the duration of syllables adjacent to accented monosyllables and polysyllables in more normal speech contexts—residual lengthening would indicate that the picture, described above, of the word as the locus of accentual lengthening may need some adjustment[13]

[13]There does not appear to be any residual lengthening effect beyond the locus associated with domain-edge processes. Indeed, there is some evidence, discussed in Section 5.5, that domain-edge lengthening may occasion *shortening* in segments near the locus. There is also a general difference in the nature of the two lengthening processes: accentual lengthening appears to have a gradient distribution within the word, with all subconstituents affected and greater effects nearer the constituent boundaries; utterance-final lengthening, as an example of a domain-edge process, is confined to certain phonologically-defined subconstituents of the word-rhyme, and there is no evidence of significant lengthening beyond those subconstituents. Thus, accentual lengthening is diffuse and gradient within the locus, whereas final lengthening, and also initial lengthening, are localised. It is possible that this difference may relate to the different articulatory mechanisms through which lengthening is implemented. Using the task-dynamic approach, Beckman *et al.* (1992) say that the closing gesture in an accented syllable is phased later, relative to the opening gesture: this means that the articulators move further in the opening gesture, before this is truncated by the onset of the closing gesture. In contrast, final lengthening is associated with an increase in gestural stiffness of the closing gesture of the syllable; thus, the articulators move to the same target as in a non-final syllable, but take a longer time to get there. Details of how the articulatory implementation of lengthening may relate to its distribution are beyond the scope of this dissertation; if there is a link between articulatory strategy and distribution, however, it may be that apparently different durational effects beyond the locus—compensatory shortening for domain-edge processes, residual lengthening for pitch accent—are a reflection of these distinct articulatory strategies for lengthening within the locus.

5.4.3 The domain of accentual lengthening

The question of the domain of accentual lengthening, discussed in Chapter 2, remains unclear. In Experiment 2, the accent on the keyword is usually—though not always—the last in the utterance[14]; in such cases, it is, by definition, the nuclear accent. If accentual lengthening only affected nuclear-accented words, then the domain of accentual lengthening could be said to be the intonational phrase. It seems highly probable, however, that prenuclear pitch accents also cause lengthening: for example, Silverman & Pierrehumbert (1990:103) provide data on tonal alignment which support a "parallel phonological and phonetic treatment of nuclear and prenuclear pitch accents", also suggesting that the magnitude of lengthening of the accented syllable may be greater for nuclear accents than prenuclear accents[15]. As discussed above, the distribution of lengthening within the accented word may be different for contrastive and non-contrastive nuclear accent. Thus, it may be that there are a number of levels of pitch accent distinguished by the magnitude of accentual lengthening and its distribution within the locus. If there is a hierarchy of accentual lengthening, the different levels might be associated with different domains.

One theoretically attractive approach would be to identify each prosodic constituent with a particular level of prominence: thus, each constituent would be associated with a certain degree of initial and, at least in some cases, final lengthening, and also with a particular degree of lengthening within the accented word, which is the head of the constituent. Beckman & Edwards (1990, 1994) suggest a link between hierarchies of constituents and prominences; however, although the word may be associated with lexical stress and the intonational phrase with nuclear pitch accent, it is not clear what prominence should be associated with other levels such as the utterance or the phonological phrase, and as discussed in Chapter 2, no constituent has been identified which contains only a single prenuclear pitch accent.

Selkirk (2002) suggests that domain of contrastive focus may in fact be the intonational phrase and the domain of what she calls "presentational focus"—which may be equated with non-contrastive pitch accent—is the major phonological phrase. This may be useful from the point of view of timing if it is shown, as discussed above, that contrastive and non-contrastive accent are associated with differing degrees and distribution of lengthening; however, not all intonational phrases contain a contrastive focus.

[14] Utterances in which subjects realised an additional accent following the accented keyword were not excluded from the analysis in this experiment. Such utterances made up 5.8% of the total. In some of these utterances, the accent on the keyword is consequently prenuclear; in other cases, the following accent is in a separate intonational phrase.

[15] Silverman & Pierrehumbert (1990) do not provide data on the magnitude of prenuclear and nuclear accentual lengthening.

To say that a phrase is a domain of pitch accent, of whatever type, does not localise the durational effect of accent in the way that a similar statement regarding domain-initial or domain-final processes allows the locus of lengthening to be identified: the placement of accents within an intonational phrase is influenced by non-structural factors, in particular, the pragmatic interpretation according to context. Thus, the theoretical utility of the concept of the domain is more evident with regard to the description of domain-edge processes than to accentual lengthening. The results of Experiment 2 indicate that there are at least two or three levels of domain-initial durational effects, all having a syllable onset locus; there may also be at least two levels of domain-final lengthening, affecting different constituents of the word-rhyme. In these cases, to specify the domain of the initial or final effect provides important information as to its relative magnitude and, for final lengthening, its locus. For the purposes of predicting durational variation associated with pitch accent, however, the important information appears to be that there is an accent on a word of particular length and syllable structure. It remains to be seen whether the type of accent should also be specified, for example, if prenuclear accentual lengthening is of lesser magnitude than nuclear accentual lengthening, or if the distribution of contrastive accentual lengthening is different within the locus to that of nuclear accent.

5.5 Compensatory effects

The term "compensatory" is defined in Chapter 4 as characterising durational effects in which some constituent shortens or lengthens, apparently as a result of an opposite durational variation elsewhere, whatever the underlying interpretation for the effect. In Experiment 2, there are three observations which may be interpreted as compensatory shortening: following word-initial lengthening; following phrase-initial lengthening; and preceding utterance-final lengthening. There is no strong evidence for relating these observations directly to constituent edges or to constituent length, or to any other source of suprasyllabic durational variation. In two out of three cases, they arise from comparisons between segmental durations in contexts that are not phonetically balanced, which means that durational effects arising from the adjacency of segments cannot be ruled out.

The observations suggesting compensatory shortening are reviewed here and possible interpretations are suggested. The existence of compensatory processes remains to be confirmed by experiment, however: suggestions for such research are advanced in Chapter 6.

5.5.1 Evidence for compensatory shortening

Word-initial lengthening and compensatory shortening

In the word-edge and word-span analysis presented in Chapter 4, the test syllable nucleus for right-headed keywords is slightly shorter in monosyllables compared with disyllables. For example, in:

Series A.1 JOHN saw Jessica **mend** it AGAIN.

Series A.2 JOHN saw Jessie **commend** it AGAIN.

the /ɛ/ in /mɛnd/ is slightly shorter in *mend* than in *commend*, particularly in the accented condition. This effect, which may be seen in Figure 4.4 in Chapter 4, is not significant, but runs counter to the trend for the nucleus in the accented disyllable vs trisyllable comparison, and also for other subsyllabic constituents in the accented condition: in all other cases in right-headed and left-headed keywords, the duration of test syllable subconstituents is greater in accented monosyllables than in accented disyllables. The syllable onset undergoes a large amount of lengthening in the monosyllable compared with the disyllable—31ms (32%) in accented words, 17ms (21%) in unaccented words—and the shortening of the nucleus in the same comparison suggests a compensatory relationship.

Compensatory shortening of the syllable nucleus following word-initial lengthening has not previously been noted. This is to some extent because some studies finding evidence for word-initial lengthening report only onset duration. Turk & Shattuck-Hufnagel (2000), however, report the duration for American English of the syllable centre as well and, as discussed in Section 5.2, they do not observe a consistent word-length effect in the syllable centre in right-headed keywords: in particular, in the accented condition, the /oʊ/ in *pose* is only slightly longer than in *oppose*, and this difference is not significant by Subjects. The polysyllabic accent hypothesis would predict a larger difference in this case, arising from the attenuation of accentual lengthening of /oʊ/ in the disyllable. It may be that the compensatory shortening following the large word-initial lengthening of /p/ in *pose* serves to mask the greater accentual lengthening in the monosyllable[16].

[16] In some of their materials, Turk & Shattuck-Hufnagel (2000) have complex stressed syllable onsets, such as /kw/ in *choir* vs *acquire*. As discussed in Chapter 3, only the first consonant in such onsets are included in the initial consonant measure, and the other consonant is measured as part of the "syllable centre", in order to facilitate accurate segmentation. It is to be expected that both parts of a complex onset would show initial lengthening; thus, in three out of 11 cases, the durational effect on the syllable centre may overestimate the lengthening of the nucleus in monosyllables compared with disyllables, because the syllable centre includes an onset consonant. This could make any underlying compensatory shortening less apparent.

Phrase-initial lengthening and compensatory shortening

In the utterance-span analysis presented in Chapter 4, there is a comparison of test syllable subconstituent duration between Series B.3 and Series D.3 utterances for right-headed keywords, such as:

Series B.3 I MADE Peter Burgundy **send** to them ALL.

Series D.3 Will you **send** it TODAY please.

There is evidence of lengthening of test syllable onsets in Series B compared with Series D, suggesting that in some cases the test syllable may be preceded by a phrase boundary (such as a phonological phrase boundary). There is also some evidence of shortening of the coda for certain keywords in the utterance-medial (Series B) sentences, although this result is not significant across all keywords. These two observations suggest that there may be a compensatory relationship between onset duration and coda duration[17].

Utterance-final lengthening and compensatory shortening

In Chapter 4, there is also a comparison between Series B.3 and Series D.3 for left-headed keywords, such as:

Series B.3 I SAW the **mace** unreclaimed by them AGAIN.

Series D.3 Albert THREW the **mace** again.

There is evidence of lengthening of the coda in Series D.3, which may be due to the utterance-antepenultimate position of the syllable. There is also evidence of lengthening of the onset in Series B.3; the structure of the sentences suggests that this is unlikely to be phrase-initial lengthening. The explanation may be compensatory shortening of the onset in Series D.3 due to lengthening of the coda. Compensatory effects are not observed in Experiment 2 in other analyses of utterance-final lengthening, for example, where the test syllable is in absolute-final position, the rhyme is lengthened and there is no durational effect on the onset.

Compensatory shortening of the onset in response to final lengthening of the syllable rhyme has not been reported previously; Turk (1999), however, reports shortening

[17] An alternative interpretation is that the coda is shortened due to domain-span compression in the longer Series B utterances. This is unlikely, however, because the effect on the coda is preserved in a comparison using Series B.1 sentences, which are structurally similar to the Series B.3 sentences, but are two syllables shorter and little longer than the Series D.3 sentences. There is a possibility of segmental effects confounding the comparison, however. For example, in the *send* sentences illustrated above, the coda is followed by a consonant in the B.3 sentence, but by a vowel in the D.3 sentence: it is not clear if shortening in consonant clusters occurs between, as well as within, syllables; if it does, then this represents an alternative explanation for this particular comparison.

for one of two speakers on the rhyme of the unstressed syllable preceding the phrase-final stressed syllable.

5.5.2 Interpretations of compensatory shortening

One possible interpretation of compensatory effects is described by de Jong (1991:7): "given an actual situation in which the ratio between consonant and vowel duration is held constant, variation in the placement of the boundary mark between consonant and vowel could, by itself, generate a negative correlation." Thus, a compensatory effect could arise from random fluctuation in measurement, but this is unlikely to underlie the observations in Chapter 4: the variation in onset duration associated with word-initial lengthening is large and is systematic rather than random; furthermore, the compensatory effects associated with phrase-initial lengthening and utterance-final lengthening are between non-adjacent segments.

It is possible, however, that compensatory shortening may have a similar explanation in terms of articulation: structurally-determined lengthening, such as that observed at domain edges, may cause a change in the articulation of the segments within the locus of lengthening which affects the acoustic realisation of the boundary between these segments and adjoining segments, and thus affects the identification of that boundary when segmental durations are measured. This could only explain the compensatory shortening associated with word-initial lengthening, where the lengthened and shortened segments are adjacent. This effect is, however, the most robust of the three possible compensatory effects, as the measured segments have a consistent phonetic environment[18].

Alternatively, the articulatory change within the locus may cause changes in the articulation of adjoining segments which could have durational consequences for those segments. In their task-dynamic approach discussed in Section 5.4, Beckman & Edwards (1994) suggest that accentual lengthening is associated with changes in gestural phasing and that final lengthening is associated with changes in gestural stiffness. It is possible that these mechanisms could have consequences for the articulation and duration of adjacent segments. It not clear whether this alternative articulatory interpretation could explain compensatory effects between segments which are not adjacent—for example, variation in articulation of the onset could have articulatory consequences on the coda, which could affect its duration—and details of the mechanisms which could underlie such an effect are beyond the scope of this dissertation. One question for future investigation is whether such effects would be expected to

[18] Although not statistically significant, the effect associated with word-initial lengthening represents, for accented words at least, a small shortening effect where there are good grounds for expecting a lengthening effect.

be symmetrical: that is, whether changes in the articulation of a lengthened segment could affect how segments preceding it are articulated, as well as those following it.

An alternative interpretation of compensatory processes is that they arise from a domain-span process at the syllable level. This suggests that syllable durations are derived initially—taking into account prominence, position, stress distribution etc.—and the durations of subsyllabic segments are adjusted subsequently. This is termed "syllabic mediation" by van Santen (1997), who expresses the concept thus: "The duration of a segment depends mostly on the (pre-computed) syllable duration and the segment's identity [...When] two contexts produce the same overall duration of a given syllable, then all segments should also have the same duration in the same contexts" (van Santen 1997:237)[19]. Thus, if syllables have pre-calculated durations, lengthening in one part of the syllable—for example, word-initial lengthening of the onset—would cause a similar amount of shortening elsewhere; segmental durations outside the syllable should not be affected by lengthening effects within the syllable.

All of the observations of compensatory shortening reported above are compatible with the syllable-span hypothesis in terms of direction, but not in terms of magnitude. In particular, the compensatory shortening of the nucleus is not commensurate with the word-initial lengthening of the onset: total syllable duration is greater in word-initial position than in word-medial position. Furthermore, if they exist, syllable-span effects should be ubiquitous; as noted above, however, the onset of the utterance-absolute-final syllable shows no compensatory shortening in Experiment 2, despite the very large lengthening effect in the syllable rhyme.

Another interpretation of compensatory shortening is predicated on the existence of domain-span processes in higher-level constituents: thus shortening would occur in response to a lengthening effect in order to maintain the duration of some superordinate unit. The evidence from Experiment 2 indicates that such processes do not occur at the word level or the utterance level; in addition, evidence discussed in Chapter 2 suggests that such processes do not occur in prominence-delimited units such as the cross-word foot.

Compensatory shortening: summary

The most likely interpretation of compensatory effects appears to be that there is some articulatory adjustment in the locus of lengthening that affects how the boundary between the locus and the following segment is realised: this could account for shortening of the nucleus following word-initial lengthening. Whether a more complex articulatory explanation is required to explain the other observations of compensatory

[19] Van Santen rejects the syllabic mediation hypothesis, partly because of the localisation within the syllable of factors such as phrase-finality, word-initial position and lexical stress.

shortening is uncertain: the effects associated with apparent phrase-initial lengthening and utterance-final lengthening arise from comparisons between materials which are not phonetically balanced, and may simply be anomalous results.

5.6 Summary

The evidence reviewed in this chapter suggests that the primary processes associated with suprasyllabic linguistic structure are domain-edge lengthening and accentual lengthening, both of which are associated with phonologically-defined loci. The number of hierarchical levels of constituent structure associated with domain-initial and domain-final lengthening processes remains to be established, as does the number of levels of phrasal stress differentiated by variations in the magnitude and distribution of accentual lengthening.

There is evidence for one type of domain-span process—word-rhyme compression—but this may also be interpreted as a word-final process. The existence of domain-span processes at the word level and the utterance level is not supported in Experiment 2, and examination of previous experiments suggests that support for these domain-span processes may be reinterpreted, although in a few cases results suggest a different picture from that indicated by Experiment 2.

In Chapter 6, a model of suprasyllabic speech timing is outlined which incorporates these processes, and the principles encapsulated by this model are contrasted with other views of suprasyllabic speech timing processes. Suggestions are made for further research which explores questions about the nature of domain-edge lengthening and accentual lengthening raised in the present chapter.