Prominence in Tamil

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This paper investigates whether or not there are phonetic correlates of prominence at the word level in Tamil that can be associated with word-initial stress. There is no lexically distinctive stress but there are indications in previous work – based on impressionistic judgements and experimental evidence of vowel reduction patterns – that word-initial syllables may be prominent. Sets of words containing segmentally identical syllables in different positions within the word, e.g. [**n̪a**ɾikʉ], [kan̪**a**ʋʉ] and [ʷoːɖin̪**a**], were recorded by five speakers in a carrier phrase. The prosodic properties of the test syllables were compared to establish whether syllable position had a significant effect. No consistent results were found for either duration or loudness: their role at the word level in Tamil seems to be confined to marking intrinsic segmental and quantitative distinctions. Significant differences in F0 related to syllable position would be consistent with initial syllables bearing abstract word-level prominence. This would be marked primarily through the association of phrasal pitch accents, unaccompanied by independent differences of loudness or robust durational effects.

1 Introduction

Speakers structure utterances by giving greater prominence to some constituents than others. This is true at the level of the individual word in many languages: one or more syllables stand out as more prominent than the rest and are typically described as bearing lexical stress or word-stress. It is also true of higher levels of prosodic organization: in a sentence one or more constituents may bear phrasal stress or accent. The phonetic correlates of prominence at different levels may vary, as has been demonstrated in recent work seeking to differentiate phrase-level accent from word-level stress (e.g. Beckman & Edwards 1994, Sluijter & van Heuven 1996, Suomi, Toivanen & Ylitalo 2003).

Correlates of word-level prominence differ cross-linguistically but often involve differences of duration. Spectral balance may also be a correlate (Sluijter & van Heuven 1996) and in some languages vowel quality differences play an important role. Pitch too may be involved, as a lexical property in so-called 'pitch accent' languages, such as Japanese (Beckman 1986). In other, so-called 'stress accent' languages there may be F0 movements associated with lexically stressed syllables, but the assumption that F0 is a direct correlate of word-level prominence has been largely discredited (Vanderslice & Ladefoged 1972, Pierrehumbert 1980, Beckman & Edwards 1994). According to autosegmental-metrical theory (Pierrehumbert 1980, et seq.), there is instead a relation between the alignment of the pitch accents of the intonation contour and the prominence pattern of the phrase. F0 patterns therefore primarily mark prominence at a higher phrasal level, and reflect word-level prominence distinctions only indirectly.

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Not all languages mark prominence at every prosodic level: it has been claimed, for instance, that Indonesian is entirely without relations of prominence within the word (Goedemans & van Zanten, forthcoming). This suggests that there may be a typological distinction between those languages that have word-level structural prominence and those that do not. It is not at all clear where Tamil fits in: there is no lexically distinctive stress in Tamil, nor is there any evidence that pitch functions contrastively at the word level. Previous work, which is largely impressionistic, has reached no consensus on the existence or location of word-level stress. There are, however, several indications that the initial syllable has some prominence (e.g. Caldwell 1856: 142, Beythan 1943: 21, Balasubramanian 1980: 456), including experimental evidence from patterns of vowel reduction (Keane 2003).

This paper tests the hypothesis that there are consistent differences in duration, loudness and F0 giving prominence to initial syllables in Tamil. Sets of test words were selected, organized in triplets such that identical syllables occurred in initial, medial and final position, e.g. [**n̪a**ɾikʉ], [ka**n̪a**ʋʉ] and [ʷoːɖi**n̪a**]. This allowed acoustic properties to be compared across syllable positions, whilst controlling for segmental effects. A significant difference in at least one of the three parameters measured would be consistent with structural prominence, at the lexical or phrasal level. Negative results would leave open the possibility that the language lacks prominence distinctions at the word level.

The next section will review previous work on the prosodic characteristics of Tamil, as background to the description of the experiment in the following section. The results are analyzed in section 4 and their implications for the prosody of Tamil discussed in the final section.

2 Background

2.1 Word-level prominence

Although the segmental make-up of Tamil has been studied extensively (e.g. Firth 1934, Fowler 1954, Balasubramanian 1972, Rajaram 1980, Marthandan 1983, Keane 2004), little attention has been paid to its prosodic characteristics, or indeed those of any other Dravidian language (Krishnamurti 2003: 59). Previous discussions of prominence in Tamil have concentrated almost exclusively on the issue of word-level stress, and reached conflicting conclusions. One body of opinion, voiced by Arden, denies the existence of stress in the language altogether:

> There is no accent in Tamil. All syllables are pronounced with the same emphasis. (Arden 1934: 59; see also Pope 1859: 22, Jones 1967: 138, Arokianathan 1981: 5, Soundararaj 2000: 248)

Note that, although Arden uses ‘accent’ to refer to word-level prominence, in the present paper the term is reserved for prominence at the phrase level. Others accept the occurrence of phonological lexical stress but differ over its location: Andronov, for instance, (1973: 114) claims that stress is free or dynamic in modern Tamil, and that this constitutes a change from the classical language. Marthandan, whose judgements are largely based on proprioception, also admits some variation in stress placement:

> Position of stress in the word is by no means fixed to any syllable of the individual word; yet in connected speech it is found more often than not in the initial syllable of the word except in cases of words of emphasis. (Marthandan 1983: 309)

Certainly the initial syllable of the word is the preferred location amongst those who argue for a fixed stress system (e.g. Caldwell 1856: 142, Beythan 1943: 21, Trubetzkoy 1939/1969: 297). This word-initial position coincides with stem-initial position, since prefixation, if it exists at all in Tamil,[1] limited to a handful of syllables which could be considered separate pronouns. Initial prominence would thus mark out lexical morphemes, in opposition to inflectional suffixes. This relation with the morphological structure of the language, noted by both Caldwell (1856: 142) and Beythan (1943: 21), may suggest a boundary-marking function for prominence. With one or two exceptions, therefore, these impressionistic descriptions are consistent with the idea that initial syllables receive some kind of weak prominence in Tamil.

Descriptions of the phonetic nature of prominence in Tamil are limited and largely inconclusive for non-emphatic speech. Loudness is implicated in some descriptions (e.g. Ravisankar 1994: 87), but experimental work conducted by Balasubramanian failed to find any consistent correlation between intensity and word-level stress. A Frøkjaer meter was used to measure intensity at the midpoint of vowels in 63 words produced in isolation (Balasubramanian 1972: 507). This revealed only small intensity differences in normal utterances (i.e. without contrastive stress), which Balasubramanian attributes to inherent differences in the quality of the vowels concerned. He lends tentative support to the first syllable being the locus of stress for words in isolation, on the basis of his own intuitions as a native speaker and results for emphatic stress (summarized below). In non-emphatic speech, however, his experimental investigations produced no significant results, leading him to conclude:

> At the moment I have no solid evidence regarding which syllable of a polysyllabic word in Tamil is stressed. (Balasubramanian 1980: 453)

In addition to intensity, Balasubramanian's empirical work also encompassed measurements of vowel duration. The Tamil vowel system involves quantity distinctions, and he established that these were reflected phonetically by significant durational differences, reporting ratios of short to long ranging from 1:1.6 to 1:2.4 (Balasubramanian 1972: 179). He concluded that, once intrinsic segmental differences are taken into account, vowel duration in Tamil is affected primarily by phonological length and the structure of the syllable in which the vowel occurs, not syllable position per se (Balasubramanian 1980).

There are, however, some indications that duration may also be involved in word-level prominence, at least for a restricted class of segments. Acoustic analysis reported in Keane (2003) investigated vowel reduction, which had been observed impressionistically in Tamil (e.g. Christdas 1988: 193, Schiffman 1999: 17) and has been associated with stress in other languages (e.g. Fourakis 1991 for American English, Koopmans-Van Beinum 1980 and van Bergem 1993 for Dutch). The occurrence of vowel reduction was confirmed: tokens of /i/, /a/ and /u/ in initial syllables were found to be of more peripheral vowel quality than their counterparts in word-medial and final syllables. Duration was also implicated: non-reduced tokens of /a/ and /u/ were significantly longer, and the same was true of /i/, but only for a restricted set of data. Investigation of the /ai/ diphthong (Asher & Keane 2005) also found reduced duration in non-initial syllables. However, neither study controlled for phrase-level prominence in any systematic fashion. A post hoc check on a small set of /a/ vowels restricted to phrase-final words, on the grounds that these seem not to bear phrasal stress, replicated the pattern of qualitative vowel reduction but interestingly did not find any significant results for duration (Keane 2003: 1259).

Descriptions of F0 contours in Tamil tend to focus on phrase-final movements, since it is here that different utterance types are most clearly distinguished. There are, however, some references to F0 movements being associated with word-initial syllables, such as Asher's claim that intonation peaks fall most commonly on the first syllable of a tone group (Asher 1982: 232) and Balasubramanian (1980: 456) noting that 'the most important item' (or items)

[1] Christdas (1988: 390) and Zvelebil (1990: 16) present arguments on either side of the debate over whether the initial vowels of pronouns such as *a-van* 'that man' and *i-van* 'this man' are prefixes.

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in a statement have a pitch rise on the first syllable and a fall over subsequent syllables. A much more detailed description is given by Soundararaj (1986, 1987), who focuses on the location of F0 peaks. According to him, these fall predominantly in the second syllable, and he proposes certain rules for determining their location, depending on syllable structure (Soundararaj 2000). He regards these F0 peaks as the 'invariant phonetic correlate of prominence in Tamil words' (Soundararaj 1987: 29), and argues (Soundararaj 2000: 246) that Tamil has pitch accent, not stress accent, on the grounds that the syllables in which the peaks fall are not consistently marked by increased duration and intensity.

The inconclusive nature of the findings for non-emphatic utterances contrasts with clearer results obtained in studies of emphasis or contrast. Unfortunately terms such as 'contrastive stress' and 'emphatic intonation' often lack precise definition and the conditions under which they were elicited in these studies of Tamil are not described in any detail, nor are the number of speakers specified. One investigation, reported by Balasubramanian (1981: 139), found evidence of various lengthening effects in the initial syllable of a word 'said with special emphasis': of an initial vowel (by a factor of as much as two), of word-initial liquids and approximants, of a geminate consonant in the syllable coda and of the closure phase of voiceless plosives. Non-initial syllables, however, were not measured, so it is not clear whether the effects he reports are confined to word-initial syllables. In earlier work he refers to sharp pitch rises occurring in stressed syllables when the context requires a particular word or syllable to be stressed (Balasubramanian 1972: 544). Ravisankar (1994: 43) also refers to increases in pitch level associated with emphasis and contrast, as well as loudness and duration. Further detail is provided by Asher (1982: 232), who describes emphatic intonation as involving a high pitch peak, either on the first syllable or a long vowel later in the word. Taken together these comments provide a reasonably consistent, if still sketchy, picture of emphasis and contrast in Tamil being marked prosodically in ways familiar from descriptions of other languages, i.e. heightened pitch and increased duration and loudness. However, no conclusions can be drawn from this about whether the same prosodic parameters are used to mark non-emphatic lexical stress.

In this study the words of interest were embedded in a constant carrier phrase uttered without particular emphasis. As will be discussed, the location and indeed existence of phrasal stress in Tamil are uncertain, but the test words may carry phrasal stress since they bear focus. They were chosen to contain identical syllables in different positions within the word, so that the duration, loudness and F0 of those syllables could be compared. Any significant differences in acoustic properties between initial and non-initial syllables could be interpreted as correlates of fixed stress on word-initial syllables, whether lexical or phrasal. The absence of any significant results would be consistent with the view that Tamil lacks robust acoustic correlates of word-initial stress, and may even fail to make prominence distinctions at the word level.

3 Experiment

3.1 Materials

Acoustic analysis was conducted on sets of words containing segmentally identical target syllables in three different positions – initial, medial and final. The choice of materials was restricted by a number of considerations, including the deliberate exclusion of obstruent consonants. In the native Dravidian vocabulary there is complementary distribution of different phonetic alternants, sometimes referred to as Caldwell's Law (Caldwell 1856: 102). In word-initial position voiceless plosives are found, voiced stops occur word-internally after nasal segments, and intervocalically the exact realization depends on the place of articulation: for dentals there is variation between a voiced stop and fricative, for bilabials there may be

Table 1 Test words organized according to the position of the target syllable (emboldened).

	Initial		Medial		Final	
ʋan̪	**ʋan̪**d̪iːɾkaɭ 'you (pl.) came'	வந்தீர்கள்	a**ʋan̪**d̪aːn̪ 'he himself'	அவன்தான்	kiɻa**ʋan̪** 'old man'	கிழவன்
maː	**maː**sat̪il 'month.loc'	மாசத்தில்	sa**maː**n̪am 'equality, comparison'	சமானம்	maɾa**maː** 'tree.question'	மரமா
n̪a	**n̪a**ɾikʉ 'fox.dat'	நரிக்கு	ka**n̪a**ʋʉ 'dream'	கனவு	ʷoːɖi**n̪a** 'who ran'	ஓடின
n̪i	**n̪i**miʃam 'minute'	நிமிஷம்	ka**n̪i**ʋʉ 'ripeness, tenderness'	கனிவு	gaʋa**n̪i** 'take care'	கவனி
ʋaː	**ʋaː**ɾatil 'week.loc'	வாரத்தில்	si**ʋaː**dʒi (personal name)	சிவாஜி	koɳɖʉ**ʋaː** 'bring!'	கொண்டுவா
ʋi	**ʋi**ɾʉpʉ 'desire, wish'	விருப்பு	t̪a**ʋi**ɾa 'except'	தவிர	man̪aɪ**ʋi** 'wife'	மனைவி
n̪eː	**n̪eː**ɾat̪ilaː 'time.loc.qs'	நேரத்திலா	pad̪i**n̪eː**ɻʉ 'seventeen'	பதினேழு	paːɖʉn̪aː**n̪eː** 'he really sang'	பாடுனானே

further weakening to an approximant, for retroflex sounds either a voiced stop or a flap is found and several possibilities have been reported for velars, including a voiceless palatal fricative, voiced and voiceless velar fricatives, and the voiced glottal fricative [ɦ]. Such wide phonetic variation could of itself introduce differences which would be hard to disentangle from effects of syllable position, so sonorant consonants only were included in target syllables, as their phonetic properties are much more stable. They are also voiced, giving an unbroken F0 trace throughout each target syllable. Of the sonorants only a subset are permitted in word-initial position by the native phonotactics, i.e. /m, v, n, r, j/. Furthermore, there are also restrictions on syllable rhymes: of the vowels only /a, u, i, aː, eː, oː/ can occur word-finally in words of more than one syllable, and there is a constraint on word-initial syllables against /v/ preceding a back vowel and /j/ preceding a front vowel. Seven triplets containing target syllables that conform to all of these restrictions are displayed in the rows of table 1. Within each triplet the number of syllables was held constant, with trisyllabic words being used in all but the final triplet.[2]

Each word was presented within the following carrier phrase:

kumaːɾ __ ʲɛn̪d̪ɾaːɾ[3] Kumar said '__'.
குமார் __ என்றார்.

Since some of the words are verb forms and unmarked Tamil word order is verb-final, reported speech was used so that the position of the word within the sentence could be held constant, to avoid words being differentially affected by any prosodic properties related to position within the phrase. No explicit instructions were given about how sentences should be produced, since the aim was to elicit unmarked statements, without strong emphasis at any point. Nevertheless, the fact that the word containing the target syllable invariably represented the new information made it the most likely bearer of focus.

[2] An initial set of recordings in which the number of syllables per word varied within a triplet showed such a high correlation between duration and syllabic make-up that other differences were effectively obscured.

[3] The rhotic liquid represented orthographically by <ற> is produced with a preceding epenthetic stop when written as a geminate or following a nasal, and this is reflected in the transliteration as <n̪d̪ɾ>. There was variation between and within speakers over the presence of on-glides at the start of [ʲɛn̪d̪ɾaːɾ] and also [ʷoːɖin̪a]; this is consistent with observations elsewhere in the literature (e.g. Keane 2004).

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The sentences were presented in Tamil orthography, one at a time on a computer monitor, and subjects controlled the rate of display by pressing a key to move onto the next sentence. There are two main varieties of Tamil, formal and colloquial, and the differences between them are sufficiently great for the language to be classed as diglossic (Britto 1986). Written texts are generally formal, although orthographic representations of colloquial Tamil are becoming more common. The materials for this study were relatively colloquial in character, and this is reflected by forms such as [ʷoːɖin̪a] ([ʷoːɖijaðʉ] in formal Tamil).

Four randomized orders for the sentences were produced, one of which all subjects completed first as a trial run. They then read through the other three sentence sets, with short breaks in between, using a different ordering of the three for each speaker. There were therefore 63 target tokens per subject, and any sentences over which the speaker stumbled were re-recorded at the end.[4]

3.2 Speakers

Five speakers were recorded; three were female and two male. They formed a fairly homogeneous group both in terms of age and dialect. They were all between 22 and 24 years old, and had spent most, if not all, of their childhood in Chennai.

3.3 Measurements

All recordings were made in a sound-proofed booth in Oxford University Phonetics Laboratory and digitized at a rate of 16 kHz (16 bit resolution). For each sentence auditory and visual cues were used to make a series of duration measurements, including marking the start- and end-points of each target syllable and its vowel. Realizations of /ʋ/ varied along a continuum between fricative (as in figure 1) and approximant.[5] The offset and onset of a strong first formant were taken as the boundaries in each case: even in the more approximant-like realisations they could be identified with a reasonable degree of confidence. As figure 3 illustrates, there were generally clear spectral discontinuities at the boundary between nasals and vowels, and the end of F2 structure was taken as the offset of a nasal preceding a voiced stop. The same criterion, i.e. end of F2 structure, was also used to segment the vowel-affricate sequence in [si**ʋaː**dʒi] and the vowel-fricative sequence in [**ma**ːsat̪il]. A sharp drop in the amplitude of F2 was taken as the boundary between a vowel and a following tap. For the vowel-rhotic boundary in [pad̪i**n̪eː**ɻʉ] a marked reduction in the amplitude of F3 as it dipped downward provided the clearest landmark.

One potential point of difficulty was reliably identifying the boundary between a vowel-final target syllable and [ʲɛn̪d̪raːr] in cases where no pause intervened. An example of such a sequence is provided in the spectrogram in figure 1: here the word-final vowel is [i] and the boundary is placed at the point where F2 begins to fall. A further problem is illustrated in figure 3 (see section 4 below), where the rate of vocal fold vibration drops markedly at the transition between the vowels. In this example the boundary was placed between the two most widely spaced pulses. Figure 5 (see section 4 below) illustrates a case with word-final [a]: in such instances the boundary was placed at the onset of divergence between F1 and F2. Note that this policy differs from the criteria used to mark the boundary after [a] in word-initial and word-medial syllables. This is a general problem: the difference in context between final syllables, which are followed by either pauses or a glide, and initial and medial syllables,

[4] A further triplet was included in the materials, but the results are not reported here due to problems with the segmentation.

[5] The variation between [v] and [ʋ] found in the data seems to be true of Tamil speech in general. Since the principles determining the relative distribution of the two variants are unknown, a policy of consistency has been adopted in the transcriptions, and thus the approximant symbol appears throughout.

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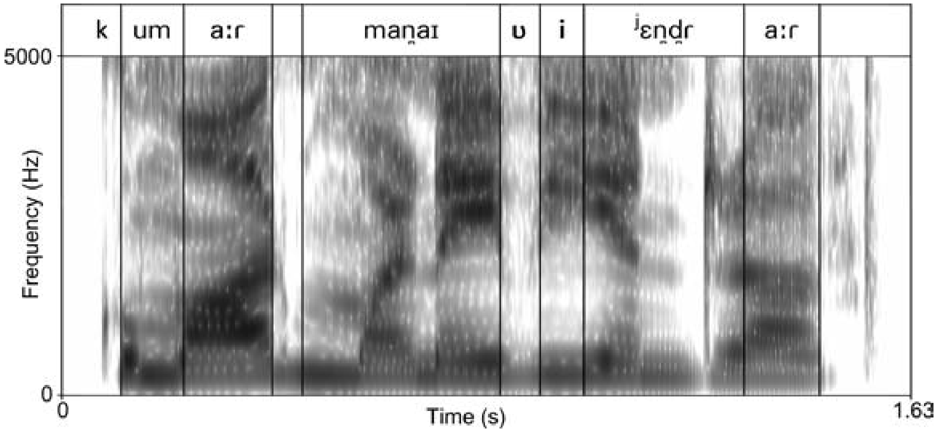

Figure 1 Spectrogram of the sentence [kumaːɾ man̪aɪʊi ʲɛn̪d̪ɾaːɾ] spoken by speaker SR, with segmentation boundaries marked.

which are followed by consonants, means that precisely comparable segmentation strategies are impossible. The measurements for final syllables were accordingly excluded from the analyses of duration.

The syllable containing the target vowel was of primary interest, but the [-aːɾ] sequences in the first and last words of each sentence were also measured in order to monitor for systematic changes in speech rate. In the case of [kumaːɾ], the spectral discontinuity corresponding to the oral release of the [m] was taken to be the starting point. In [ʲɛn̪d̪ɾaːɾ] the consistent presence of an antiformant in the high frequencies of pre-vocalic [ɾ] was used to determine the placement of the boundary. There was considerable variability in the acoustic structure of pre-pausal [ɾ]: the point at which voiced F2 structure ceased was marked as the end in each case.

The durations of both the target syllable as a whole and also the vowel by itself were measured, to allow lengthening due to word-initial strengthening (e.g. Fougeron & Keating 1997, Turk & Shattuck-Hufnagel 2000) to be distinguished from lengthening as a correlate of the prominence of the whole syllable. Word-initial strengthening is reported to affect word-initial consonants more than the following vowels, so its occurrence independently of prominence would be reflected in longer word-initial syllables, but not necessarily longer vowels. By contrast, if word-initial syllables are prominent, the expectation would be that both word-initial syllables as a whole and their vowels should prove significantly longer than in word-medial syllables.

Automatic calculations of mean loudness were performed for the region between each pair of start and end points, operating on the spectral power density derived from $L = 50$ ms wide, $1 + cos(2\pi(t - t_c)/L)$ windows, shifted by intervals of 10 ms. The loudness measure used is a good approximation of steady-state perceptual loudness and is a modified version of Stevens' Mark VII computation (itself an improved version of the ISO-R532 Method A standard noise measurement), using 0.7 octave frequency bins rather than the full- or third-octave bands for which it was originally defined (Stevens 1972, Kochanski, Grabe & Coleman 2005). The full algorithm is supplied in the appendix. This was employed in preference to RMS amplitude, since it mirrors the sensitivity of the auditory system to increased energy in higher frequency bands. Work by Sluijter & van Heuven on Dutch found that overall intensity was a reliable correlate of sentence-level accent, which is accompanied by an F0 excursion, but did not distinguish at all well between stressed and unstressed vowels in unaccented words. However, measures of intensity[6] in three higher level spectral bands (0.5–1 kHz, 1–2 kHz and 2–4 kHz) did differentiate reliably between stressed and unstressed vowels, whether or not they occurred under the accent (Sluijter & van Heuven 1996).

The F0 value at the midway point of each target syllable was also measured, and normalized by dividing each value by the fundamental frequency at the midpoint of sentence-final [-aːɾ]. This latter point was selected because of its stability – in all speakers the F0 contour on the second syllable of [ʲɛn̪d̪raːɾ] changed only gradually.

3.4 Analyses

In order to investigate possible effects of syllable position, repeated measures ANOVAs were performed for each of the dependent variables (vowel and syllable durations, vowel and syllable loudness and the normalized F0 value at the midpoint of the target syllable), taking syllable position (three levels – initial, medial and final) as a within subjects factor. Syllable type (seven levels, corresponding to each type of target syllable) was set as a second within subjects factor, so that differences due to segmental distinctions could be monitored. Repetition (three levels – first, second and third) was included as a further factor to check for order effects but in no case did this prove to be significant. Mauchly's test for sphericity was applied to the data in order to test whether the assumption of homogeneity of covariance made by the within subjects ANOVA model was met. In the restricted number of cases where this yielded a significant result the ANOVA F test was modified to make it more conservative by using the Greenhouse-Geisser test. These statistical models were designed to test the null hypothesis that there are no differences in duration, loudness and F0 related to syllable position within the word in Tamil. A significant result would indicate phonetic differentiation along the relevant parameter that might be evidence of structural prominence. The results for each of the three prosodic parameters (duration, loudness and F0) are reported below, after investigation of the variability associated with different productions of the carrier phrase.

4 Results

4.1 Interspeaker and intraspeaker variability

Individual speakers showed a fairly high degree of consistency in their productions of the carrier phrase. Due to the nature of the task, their speech was generally slow and careful: many of the sentence tokens were uttered with pauses between each word. The length and distribution of these pauses was highly speaker-specific: all the speakers had some pauses between the first and second words but three of the five speakers (NM, SR and VV) had no more than one pause between the second and third words. AA paused without exception at both points, and in all but six cases her first pause was markedly longer than her second (mean pause duration 332 ms before the target word,[7] compared to 102 ms after it). Speaker SV also paused uniformly before the target word (in 98% of cases) but in only 37% of cases after it, with a mean post-target pause duration of just 24 ms. Of those speakers with no more than one post-target pause, SR had pre-target pauses in all but ten cases (84%), with widely varying durations (mean value 418 ms). By contrast, NM had pre-target pauses in only seven sentence tokens (excluding cases where there was a stop-gap) and VV in just three examples, so that the vast majority of sentences uttered by these last two speakers contained no pauses at all.

[6] The measure used was the base-10 logarithm of the summed power (squared amplitude) Fourier coefficients in the relevant frequency band (Sluijter & van Heuven 1996: 2474).

[7] The mean pre-target pause duration is calculated from the full data set for each speaker, including those examples in which a stop-gap accounts for at least part of the period of silence.

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The occurrence of pauses in the data raises the possibility that different tokens of the carrier sentence may have been phrased in different ways, with consequences for the prosodic parameters under investigation. In fact, the F0 contours were affected very little, since they seem to be closely associated with individual words (see section 4.4 below for further discussion). The high incidence of pauses before the reported speech may reflect a natural phrase boundary but could also be an artefact of the task: speakers may have paused or drawn out the first word, which was entirely predictable, whilst reading the following, unfamiliar word. There is clear evidence of pre-boundary lengthening in this position, which is consistent with the view that speakers did place a boundary before the target word. For all speakers the first occurrence of [-aːɾ] was uniformly longer than the second, despite the second being sentence-final, where lengthening would be expected (e.g. Cooper & Paccia-Cooper 1980: 46, Wightman et al. 1992; for evidence of lengthening of phrase-final nasals in Tamil see Byrd et al. 2000). Of more immediate concern for this investigation is whether or not word-final target syllables were affected by pre-boundary lengthening associated with a break between the second and third words. The consistent insertion of pauses by speaker AA certainly implies the presence of a prosodic phrase-boundary and speaker SV also paused in a third of cases involving word-final target syllables (just seven tokens). The other three speakers inserted no more than one pause at this point but the possibility that a prosodic boundary was nevertheless present and marked only by pre-boundary lengthening cannot be conclusively ruled out. For this reason, in conjunction with the concerns about segmentation described above, statistical analyses of duration were restricted to data from initial and medial syllables.

Differences in overall speech rate are a further potential source of variability in the data. The occurrence of some pauses between words made the calculation of an overall speech rate unreliable, so the durations of the two occurrences of [-aːɾ] were analysed to see if there were significant differences in speech rate between those sentences containing word-initial target syllables and those containing word-medial target syllables. An independent samples t-test comparing the duration of the [-aːɾ] of [kumaːɾ] in sentences containing word-initial target syllables with that in sentences containing word-medial target syllables revealed no significant difference ($t(208) = .009$; ns), and the same was true of sentence-final [-aːɾ] ($t(208) = -.191$; ns). Variability in speech rate is therefore unlikely to be the cause of differences in duration between word-initial and word-medial syllables.[8]

4.2 Duration

A repeated measures ANOVA on vowel durations revealed syllable type to be highly significant, as was syllable position ($F(6, 24) = 79$; $p < .0005$ and $F(1, 4) = 26$; $p < .007$ respectively). However, their interaction was also significant ($F(6, 24) = 7$; $p < .0005$), indicating that the effect of syllable position on vowel duration varied between different syllable types. This is illustrated in figure 2, which displays the mean durations of the vowels initially and medially for each target syllable. It illustrates that the effect of position upon duration varies most obviously in the short vowels: initial syllables are longer than medial for /a/, whereas the reverse is true for tokens of /i/. This suggests that increased duration for vowels in initial syllables is not a general phenomenon but seems to depend upon segmental type.

[8] In order to establish securely whether or not differences in overall speech rate and loudness had a significant effect, the ANOVAs reported in sections 4.2 and 4.3 were also performed on normalized data, taking mean values across repetitions. Vowel and syllable durations were divided by the sum of the durations of the first and third words, and the loudness measures were normalized by dividing by the sum of the mean loudness values of the first and third words. The overall pattern of results was not affected in any way.

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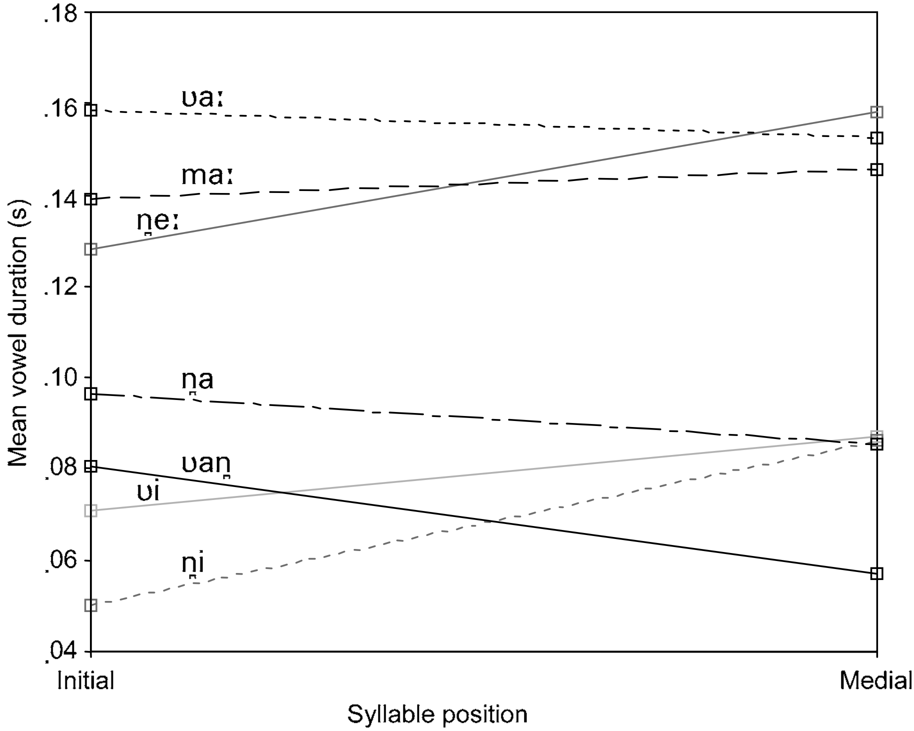

Figure 2 Mean durations across all speakers of the vowels of target syllables in initial and medial syllables.

The results of an ANOVA upon the durations of whole syllables showed syllable type to be highly significant again ($F(6, 24) = 40$; $p < .0005$), but neither syllable position (initial or medial) nor the interaction of the two factors proved significant ($F(1, 4) = 3$; ns and $F(6, 24) = 2$; ns, respectively). This suggests that there may be compensation within the syllable for variations in vowel duration, and again provides no evidence of significant durational distinctions associated with syllable position, whether due to initial strengthening or structural prominence. Rather, it appears from these data that duration simply reflects intrinsic qualitative differences and quantitative distinctions in Tamil vowels.

4.3 Loudness

A similar picture emerges from the loudness data: the significant results are associated with intrinsic segmental differences and not syllable position.[9] Thus vowel type proved to be highly significant in a repeated measures ANOVA on the vowel loudness data ($F(3, 12) = 19$; $p < .003$), whereas syllable position was not a significant factor ($F(2, 8) = 0.8$; ns). The same pattern of results was found for the average loudness computed over the whole syllable, rather than just the vowel (syllable type $F(6, 24) = 21$; $p < .0005$, cf. position $F(2, 8) = 1$; ns).

[9] Since the concerns about the reliability of the final syllable duration measures could also affect loudness, the statistical analyses were redone excluding the final syllable data. There was no material change in the results: for vowel loudness, vowel type was highly significant ($F(3, 12) = 9$; $p < .002$) but syllable position insignificant ($F(1, 4) = .004$: ns); and for syllable loudness, syllable type was highly significant ($F(6, 24) = 20$; $p < .0005$), but not syllable position ($F(1, 4) = 2$; ns).

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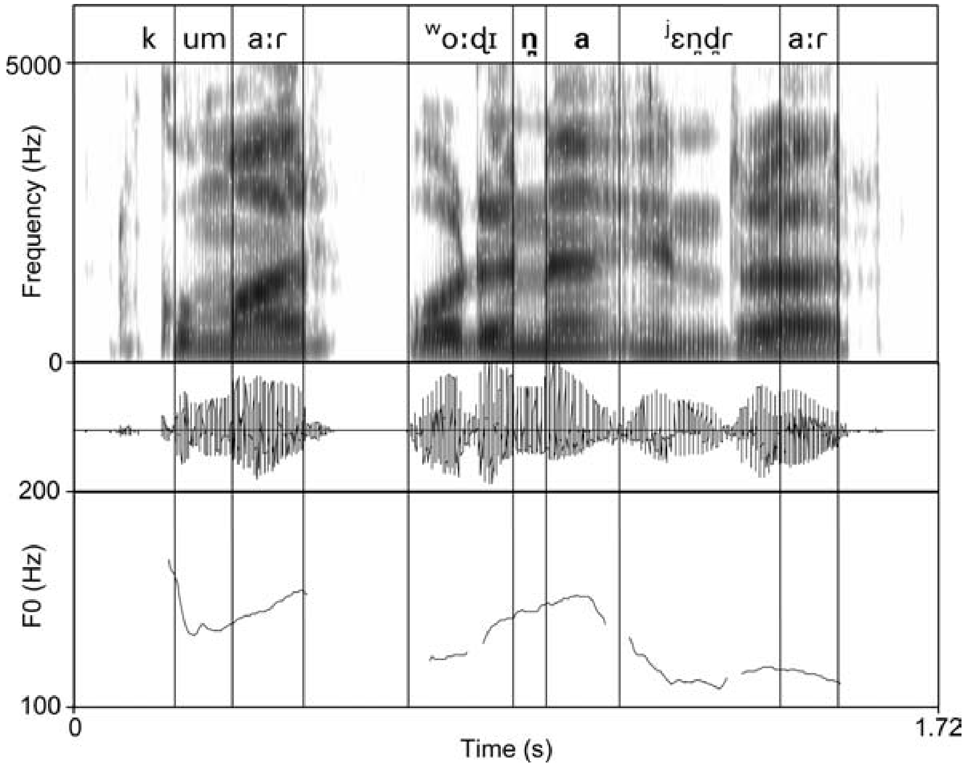

Figure 3 Spectrogram, amplitude waveform and F0 contour of the sentence [kumaːɾ ʷoːɖin̪**a** ʲɛn̪d̪ɾaːɾ] spoken by speaker SV, with segmentation boundaries marked.

Again these findings provide no evidence of the initial syllable, or indeed any other syllable position, being marked phonetically for prominence.

4.4 F0

Figure 3 exemplifies a contour that is typical of simple declarative statements in Tamil. Content words are marked by a characteristic rising-falling pattern, which involves F0 rising out of the initial syllable into a peak, usually followed by a fall within the same word. This is clearly exemplified in [ʷoːɖin̪a], where the peak occurs in the final syllable. The same rising pattern is seen in the first word [kumaːɾ] in figures 3 and 5, with the peak aligned right at the end of the word. (The steep initial fall is an artefact introduced by the aperiodicity associated with the voiceless stop.) Utterance-final constituents generally display no such rising pattern: in the first syllable the F0 typically continues the fall from the preceding word but then declines only gradually over succeeding syllables, as in figure 5.[10]

Figure 4 displays the F0 contour for the following statement as a point of comparison for the intonation patterns found in the present study.

[10] A small peak is identifiable in the F0 contour on the phrase-final word in figure 3, contrary to the general pattern described in the text. A minor obtrusion of this nature is not unparalleled in the data, but in no case does its magnitude approach that of the rises on non-phrase-final constituents.

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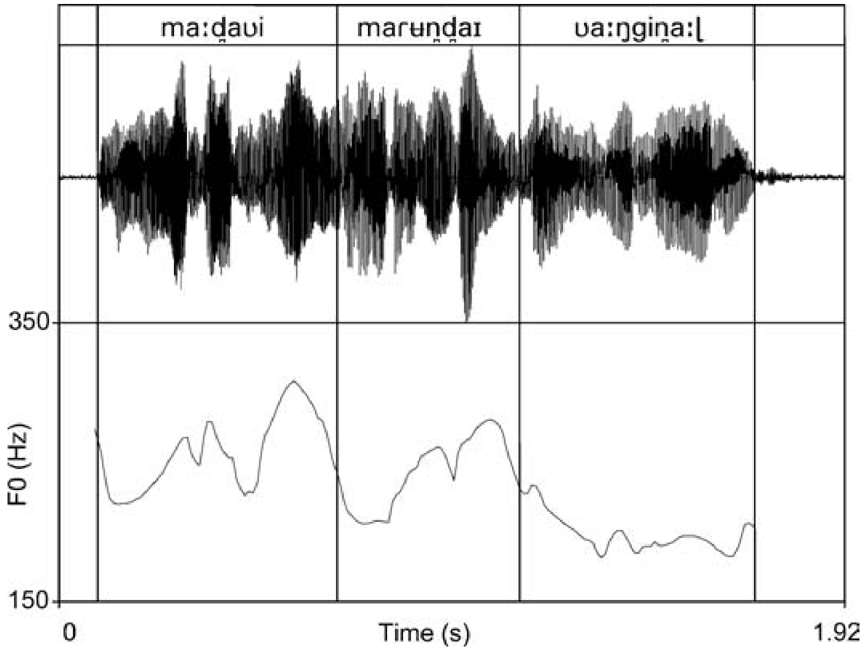

Figure 4 Amplitude waveform and F0 contour of the sentence [maːd̪aʋi maɾʉn̪d̪aɪ ʋaːŋgin̪aːɭ] 'Madavi bought medicine'.

maːd̪aʋi	maɾʉn̪d̪aɪ	ʋaːŋgin̪aːɭ
Madavi	medicine	buy.PAST.3SF

'Madavi bought medicine.'

As described above, the first two words are marked by a rise from a point within the initial syllable with peaks in the final syllable: in the utterance-final verb, by contrast, F0 continues to fall from the preceding word within the first syllable and then remains relatively flat.

The occurrence of pauses in the data had limited effect on the shape or scaling of the F0 contours: careful comparison of sentence tokens where different repetitions varied in whether or not they contained pauses revealed little difference. The only noticeable effect was that a steep initial fall during the first part of the initial syllable of the second word was more likely when no pause intervened and the F0 curve continued unbroken from the preceding word. Following a pause the F0 contour tended to jump directly to the low point, replacing the initial fall with a relatively flat or gradually climbing contour, as in figure 3.

The correct phonological characterization of the intonational tune found on declarative statements in Tamil is not yet clear. At this point there is insufficient evidence to determine whether the F0 contours that mark non-phrase-final words are most insightfully analyzed as a sequence of low and high tonal targets, or as a rising movement. Careful measurement of the alignment and scaling of turning-points is clearly a priority for future research. For this data set analysis proceeded by inspection of each F0 contour in turn. As can be seen from table 1, it was not possible to exclude voiceless segments from every syllable of the target words, just from the syllables of primary interest, and so the occurrence of associated perturbations prevented reliable measurements for many tokens.

The lowest F0 value within the target word invariably occurred at some point during the initial syllable, whether or not this was preceded by a pause. There was much more variation in the alignment of the F0 peak, with clear interspeaker differences. In AA's speech the peak appeared consistently on the final rather than the penultimate syllable, and the same was true

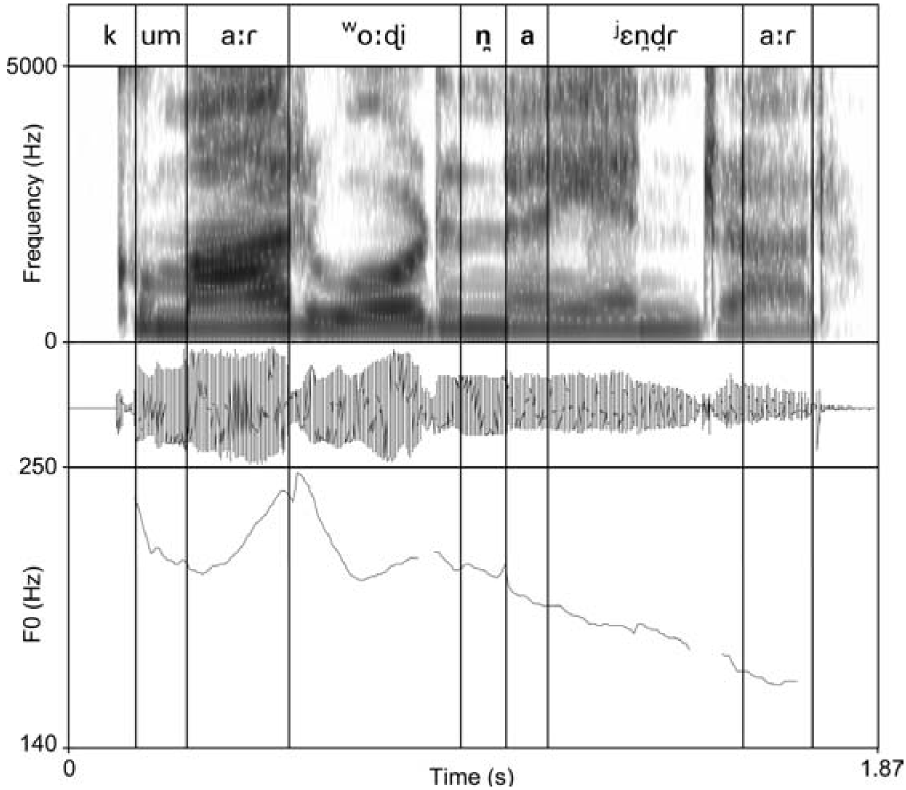

Figure 5 Spectrogram, amplitude waveform and F0 contour of the sentence [kumaːɾ ʷoːɖi**ɳa** ʲɛn̪d̪ɾaːɾ] spoken by speaker NM, with segmentation boundaries marked.

of speaker SV in the vast majority of cases (57 out of 63), although the level of differentiation between the two syllables was not so great. Speaker SR also placed the peak on the final syllable more times than the penultimate (45 out of 63), but in many instances her contours are better described as a raised plateau extending over the last two syllables, rather than a sharply defined peak. The same was largely true of VV, in whose speech the F0 maximum occurred in the penultimate syllable of nearly half the tokens (30 times out of 63).

The most radical differences, however, were found in the speech of the fifth speaker, NM, as illustrated by figure 5. She differentiated more strongly between the first occurrence of [-aːɾ] and the second than any of the other speakers, both in terms of duration and loudness. Her first word was marked by a particularly large F0 excursion, whereas the second word, containing the target syllable, had relatively little movement: in figure 5 the F0 dips to a trough and, after a slight rise on the second syllable, declines gradually over the rest of the phrase. One possible interpretation is that NM has, unusually, placed particular prominence on [kumaːɾ] and adjusted the scaling of the two F0 peaks to reflect this: the second peak may have been downstepped. Whether or not this is correct, and the reasons for this difference from the other speakers cannot be established without further research.[11]

[11] If this interpretation is correct and the word containing the target syllable has a downstepped accent in NM's data, her results are not strictly comparable with those of the other speakers. The statistical tests for duration and loudness were therefore redone, excluding NM's data. There was no change in the loudness results: syllable type remained highly significant for both vowels and syllables ($p < .0005$),

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There was also considerable variability between different words, which suggests that segmental make-up or syllabic structure may be relevant to the alignment of the peak, as suggested by Soundararaj (2000: 251). Five had peaks in the final syllable for all speakers ([kiɭa**ʋan̪**], [sa**maː**n̪am], [maɾa**maː**], [ka**n̪a**ʋʉ] and [gaʋa**n̪i**]), whereas others, notably the quadrisyllabic target words, had a high proportion of peaks in the penultimate syllable. Note that [maɾa**maː**], which ends in a question particle and might therefore be expected to show a separate pitch pattern from other words, does not appear to share any characteristics that could be associated with the question marker. Although yes/no questions containing [-aː] and declarative statements have distinct contours when they are not subordinated (e.g. Asher 1982: 232, Ravisankar 1994: 80f.), this distinction appears to be neutralized in reported speech.

Statistical tests were first performed on the normalized F0 values of all the speakers taken together, and these showed significant overall differences in F0 associated with syllable position, reflecting the rising-falling contours that have been described. In a three-factor repeated measures ANOVA on mean normalized F0 at the midpoint of the syllable, syllable position was a significant factor ($F(2, 8) = 11$; $p < .005$), but not syllable type ($F(6, 24) = 0.4$; ns). In the light of the interspeaker differences in F0 patterns that have been discussed, univariate factorial ANOVAs were also performed on syllable midpoint values for each speaker in turn, taking syllable position and type as fixed factors. Non-normalized figures were used since each of these analyses was restricted to data from a single speaker. The results reflect the exceptional nature of NM's speech: syllable position was not a significant factor for her data, although it was highly significant ($p < .0005$) for the other four speakers ($F(2, 42) = 76$ for AA, $F(2, 42) = 22$ for SR, $F(2, 42) = 112$ for SV and $F(2, 42) = 94$ for VV). Moreover, syllable position divided the data of each of these four into three homogeneous subsets (with the sole exception of VV, for whom medial and final were not significantly differentiated), but there were no homogeneous subsets at all in NM's data. Syllable type did prove to be a significant factor in the individual analyses (with the exception of SV), reflecting the variability between words mentioned above, ($F(6, 24) = 4$; $p < .003$ for AA, $F(6, 24) = 3$; $p < .012$ for NM, $F(6, 24) = 9$; $p < .0005$ for SR and $F(6, 24) = 3$; $p < .017$ for VV), but there was no significant interaction between syllable type and position, except in the case of SR.

These results confirm the conclusions based on inspection, i.e. that F0 differences, unlike duration and loudness, bear a significant relation to syllable position in the data. How these differences are to be interpreted, and what implications they have for the existence and location of word-level prominence in Tamil will be discussed in the next section.

5 Discussion

Overall these results provide partial confirmation of the hypothesis that there are consistent differences in duration, loudness and F0 giving prominence to initial syllables in Tamil. Significant differences in F0 were found, although duration and loudness play little or no part in signalling differences in syllable position within the word, instead reflecting intrinsic segmental differences and, in the case of duration, distinctions of phonological quantity. How these findings should be interpreted is less clear. They are compatible with a system of fixed lexical stress on word-initial syllables but an alternative explanation, that Tamil lacks prominence distinctions at the word level, cannot be decisively ruled out.

The findings are largely congruent with the previous work discussed in section 2 above, based largely on impressionistic observation but also a small body of experimental research.

whilst syllable position was not a significant factor. The duration figures were also largely unaffected, syllable type again proving highly significant for both vowels and syllables, but syllable position was significant for both vowels and syllables.

The absence of any significant association between loudness and syllable position is entirely consistent with Balasubramanian's (1972: 529) claim that intensity differences in Tamil can be explained with reference to segmental characteristics alone. Both the significant effect of the syllable type factor on vowel durations and the lack of a consistent effect from syllable position are also compatible with Balasubramanian's conclusion that intrinsic segmental differences and the structure of the syllable, not its position in the word, are the key determinants of vowel duration in Tamil (Balasubramanian 1980).

In assessing the relation between duration and syllable position, the present, largely negative, results should be placed in the context of previous findings. As discussed in section 2, the experimental work reported in Keane (2003) confirmed the occurrence of qualitative vowel reduction in non-initial syllables, which suggests that initial syllables do bear prominence. The results for duration provide a specific point of comparison for the /a/ and /i/ tokens in the present investigation, although the materials used in that study were more colloquial in nature. The pattern for /a/ described in section 4.2 and illustrated in figure 2 replicates the earlier findings – that /a/ vowels are significantly longer in initial than medial position. A strong effect of final lengthening was found for /i/ in Keane (2003) and appears to have been replicated in the measures for final syllables in this experiment. Tokens in medial syllables were found to be longer than their counterparts in initial syllables in both studies. However, the reverse pattern, i.e. longer tokens of /i/ in initial than medial syllables, was also reported in Keane (2003) for a small but strictly controlled data set. This comprised four reduplicated expressive words, the root of each having the structure kiC_xV_x-kiC_xV_x- e.g. [kiɾʉɣiɾʉpʉ] 'giddiness'. Comparisons were therefore made within single word tokens and the wider phonological environment of the /i/ vowels was also more tightly controlled than was possible in the current study, where the target syllable alone was held constant.[12]

Overall, therefore, the possibility that duration is a weak correlate of fixed lexical stress on initial syllables cannot be unequivocally ruled out, despite the largely negative results of the present study. The durational contrast found for the small set of colloquial data reported in Keane (2003) may reflect a genuine difference associated with syllable position for /i/, but one that was obscured in the present investigation. One possible explanation for the apparent absence of increased duration associated with the initial syllable is polysyllabic shortening, which has been claimed to operate in a number of languages (Lindblom, Lyberg & Holmgren 1981, Turk & Shattuck-Hufnagel 2000). If, as argued, syllable durations are adjusted according to the number of following syllables, initial syllables are affected more strongly than medial syllables in polysyllabic words, which might mask any lengthening of initial syllables associated with structural prominence. This possibility cannot be discounted, but duration must be a subtle stress cue if it can be masked by an opposing effect in this way. Any effect of syllable position on duration may be segment-specific and minimal in comparison with intrinsic segmental differences: at best, duration can only be a weak correlate of initial stress.

As discussed in the introduction, F0 differences should not necessarily be interpreted as a direct reflection of word-level prominence, but rather an indication that tones are associated with the test words. In principle, Tamil tones could either be lexical pitch accents, or assigned post-lexically as part of the overall intonation tune. The fact that the same word can occur in both utterance-medial and utterance-final positions, with and without the rising-falling F0 configuration, suggests that the assignment of tones is not an inherent property of the lexical item (Keane 2005). The lack of any lexical contrasts in Tamil based on accent type or alignment also counts against lexical storage of F0 patterns. Rather, it appears that Tamil tones are assigned post-lexically but closely associated with individual words in their realization.

[12] Note, however, the phonetic alternation (due to Caldwell's Law) between the initial obstruents in the two target syllables – [k] vs. [ɣ].

The phonological nature of these rising-falling contours is as yet undetermined, but seems to consist of a low tonal target followed by a high. The invariable occurrence of the lowest F0 value in the initial syllable suggests that there is a low tonal target associated with the beginning of the word. One possibility is that this is an L* pitch accent, which associates with an initial syllable as the bearer of abstract lexical prominence. Alternatively, it could be an L% boundary tone, in which case the word might lack prominence distinctions entirely. Inspection of a much larger corpus of Tamil speech than the sentences analysed in this study confirms that low turning-points are found consistently in non-final content words, even if several occur in sequence (Keane 2005). It therefore seems unlikely that they are associated with major phrasal boundaries; rather, if they are boundary tones, they must be associated with the boundary of some low-level prosodic constituent. Deciding between these two alternatives may be difficult: it is not clear that they make distinct predictions in terms of alignment. However, the way in which initial syllables are marked out by vowel reduction patterns and the cross-linguistic tendency for boundary tones to be associated with higher levels of the prosodic hierarchy both lend some support to the L* analysis.

The location of the F0 peak is far less stable. The data conform in many cases to the predictions of Soundararaj, who offers a series of descriptive rules assigning peak placement on the basis of word length and syllable structure (Soundararaj 2000: 251). However, there are also a significant number of exceptions, and considerable interspeaker variation, as described above: more research is clearly needed. The status of the low point has repercussions for how the peak is to be analysed: if the low tone is associated with an initial syllable bearing lexical stress, then the high point could be the trailing tone of a bitonal L*+H pitch accent; if the low tone is a boundary tone, however, and no syllable bears lexical stress, then the H may not be associated with any particular syllable within the word. A further alternative is that it may be a boundary tone associated with the end of the prosodic constituent, i.e. H%. More detailed data on its alignment may help to adjudicate between these possibilities.

A further issue concerns the location of phrase-level stress or accent; should this fall on the target words' they would bear both word- and phrase-level prominence. It seems unlikely that phrase-level accent falls on phrase-final words: as illustrated in figures 3–5, in declarative statements these are often the only words not to be marked by consistent clear F0 turning-points. They contain no high turning-point and it may also not be easy to identify a low turning-point, or even 'elbow' where the gradient of the fall levels out. In figure 5, for instance, the F0 contour seems simply to follow a declining base-line. At the same time, there are no firm acoustic grounds for picking out either one of the non-phrase-final words as the unique bearer of phrasal stress, since all such words are marked by similar F0 contours (with the arguable exception of NM's speech). However, the fact that the target word always represents new information does make it the likely bearer of focus.

Given that the target words may therefore bear some form of phrase-level prominence, it is important to be explicit about the limitations of these results. If these words are indeed marked by both word- and phrase-level prominence, this experiment provides no direct evidence of the correlates that distinguish words bearing phrasal prominence or accent from those that do not in Tamil. It is possible, for instance, that duration and loudness might play no role at the word level, but mark accented from unaccented words at the phrase level. Even in stress-accent languages where increased duration and intensity reflect prominence at the word level, duration may also mark accented from non-accented words at a higher prosodic level (see Turk & Sawusch 1997 and Turk & White 1999 for English, Nooteboom 1972 and Eefting 1991 for Dutch, and Strangert & Heldner 1998 for Swedish). Differences in duration associated with strong (contrastive) accent were also reported by Suomi et al. (2003) for Finnish. It would be interesting to compare accented with unaccented words in Tamil, although restrictions on what may occur in utterance-final position, where non-accenting seems to be possible, would make designing an appropriate experiment non-trivial.

The negative nature of the results for loudness permits conclusions to be drawn about word-level prominence in Tamil, independently of any phrase-level accent. It seems reasonable to infer from the absence of any relation between syllable position and loudness in the data that no such effects would be found in unaccented words either. As discussed, the situation with regard to duration is less clear but, in the absence of a robust effect of syllable position on duration in accented words, it seems unlikely that there should be one in unaccented words.

In terms of its typological classification, the results reported here allow for two main possibilities. (A third, that Tamil has lexical pitch accent, has been argued to be unlikely – tones seem to be assigned post-lexically.) The first possibility, raised in the introduction, is that Tamil belongs to a class of languages that lack structural prominence relations at the word level entirely, reserving hierarchical prominence relations for the phrase level. The evidence from this study that initial syllables are not marked by increased loudness or consistently by greater duration could be taken to support this view. Tonal targets would then be associated with prosodic boundaries, rather than a prominent syllable. The main piece of evidence against this interpretation is the occurrence of vowel reduction, which affects all but word-initial syllables. If the hypothesis that Tamil lacks word-level prominence distinctions is to be maintained, the absence of vowel reduction in initial syllables would presumably have to be viewed as essentially demarcative, and not culminative. That is, its function would be to mark the edge of the prosodic constituent, and not the first syllable as the head of the constituent.

The second alternative is that word-level structural distinctions do exist in Tamil, and that the initial syllable bears abstract lexical stress. This prominence would be realized phonetically primarily through serving as an anchor for an L* or L*+H pitch accent and also through differences in vowel quality. Loudness, however, plays no role in marking initial syllables and duration is at best a very weak correlate. It is possible, however, that these two parameters may be involved in marking contrastive focus or emphasis on initial syllables, as reports seem to suggest (Balasubramanian 1972: 544, 1980: 456; Asher 1982: 232; Ravisankar 1994: 43).

It is not possible to adjudicate definitively between these two scenarios at present, although the balance of evidence favours the second, i.e. abstract lexical prominence on word-initial syllables marked primarily by the association of post-lexical pitch features. Further investigation of F0 contours is clearly crucial as this may help to determine whether the tones are indeed pitch accents associated with syllables bearing abstract lexical prominence, or boundary tones associated with the edges of prosodic constituents. It is clear, however, that any word-level prominence that exists in Tamil is marked primarily through differences of F0 and that duration and loudness, which mark stress in many other languages, are not robust correlates in Tamil.

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Appendix

This section provides a summary account of the measure employed to calculate loudness (for full details see Stevens 1972 and Kochanski, Grabe & Coleman 2005). The loudness measure takes the band spectrum of the sound and predicts the level of a standard reference signal (consisting of a third-octave band of noise centered at 3150 Hz) that would be judged equal to it. This perceived magnitude of the standard reference signal grows as the two thirds power of its sound pressure, so that perceived magnitude doubles with each increase of 9 dB.

The spectrum of the sound is measured in terms of sound-pressure level in 0.7 octave frequency bands and each band level converted into sones (the perceived magnitude of the reference signal at a sound pressure level of 32 dB) via appendix A in Stevens' paper. The total loudness S_t of a sound is calculated from the loudnesses of the individual frequency bands by the following summation rule:

$$S_t = S_m + F(\Sigma S - S_m)$$

where S_m is the loudness of the loudest band and ΣS is the sum of the loudnesses of all the bands. The factor F (0.356) is derived from a representative value of 0.23 from Stevens' figure 5, appropriate for loudness values near 8 sones (e.g. about 68 dB SPL at 1000 Hz), scaled by interpolation from his appendix B.

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