

s about half treat them as single-segment onsets.

Finally, experimental evidence is accumulating to support the idea that the segment is the preferred representational unit in many languages, with both Arabic and English included. In line with this, good results have also been achieved in predicting SSJ results in Arabic on the basis of a pure segment model, but other factors (such as morphology) also seem to play some role. More data are required to assess the viability of the segment in certain other languages, where other units so far seem to be indicated (such as the mora for Japanese and the potentially indivisible syllable for Chinese).

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THE TIMING STRUCTURE OF CVVC SYLLABLES*

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1.0 Introduction

This paper reports on an investigation of the timing properties of particular syllable types in different dialects of colloquial Arabic. Our data are productions of sentences containing CVV, CVC, and CVVC syllables recorded by four speakers from Cairo, Alexandria, Beirut, and Damascus. We focus particularly on word-internal CVVC syllables, which are permitted in the Lebanese and Syrian dialects, but not in the Egyptian dialects. Different versions of phonological theory make possible several competing analyses of the structure of CVVC syllables; we consider these competing representations and their match with the durational properties of segments within CVVC syllable rhymes. We argue that both the phonological and the durational data support an analysis of word-internal CVVC syllables in Arabic as bimoraic, with the final consonant sharing the second mora of the long vowel.

1.1 Syllable Weight and Syllable Structures

The opposition between heavy and light syllables has long been recognized as a crucial factor in numerous domains of the grammar. (See, for example, Hyman 1985, McCarthy & Prince 1986, and Hayes 1989). The opposition is generally encoded in mora count, where a short vowel is associated to a single mora, as in (1a), and a long vowel to two moras, as in (2a). In many languages, a consonant in the coda of a syllable is also moraic (as in 2b), rendering CVV and CVC

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syllables equivalent with respect to processes that respect syllable weight:

(1) Light syllable: σ

μ
 μ
 C V

(2) Heavy syllables:

a. σ σ σ
 μ μ μ
 μ μ μ
 C V C V C V

In a language in which coda consonants are moraic, CVVC syllables should be trimoraic. However, the status of trimoraic syllables is controversial, for several reasons. First, while it is common to find monomoraic (CV) syllables patterning differently from bimoraic (CVV and CVC) syllables, evidence for a three-way distinction in syllable weight is relatively scarce. Furthermore, CVVC syllables are frequently restructured to bimoraic CVC syllables, or are limited to the edges of constituents where their final consonant can be analyzed as extraprosodic. (For arguments that word-final Arabic consonants are extraprosodic, see McCarthy & Prince 1990.) Both phenomena are illustrated by Cairene Arabic, in which CVVC is permitted word-finally but is shortened to CVC word-internally, as in *kitaab* "book" but *kitabna* "our book". Facts such as these have led various researchers to posit a universal constraint prohibiting trimoraic syllables. If this constraint is absolute (McCarthy & Prince 1986; Steriade 1991), then all CVVC syllables must actually be bimoraic; possible analyses of non-peripheral CVVC syllables are then as in (3a) or (3b), where the final consonant does not occupy a mora of its own.

(3) a. σ σ σ

μ μ μ
 μ μ μ
 C V C V C V

b. σ

μ μ μ
 μ μ μ
 C V C

But if the constraint against trimoraic syllables may be violated under certain conditions (i.e., where CVVC syllables provide the best means of satisfying more powerful constraints, as Optimality Theory predicts (Prince & Smolensky 1993; McCarthy & Prince 1993)), then CVVC syllables may in fact be trimoraic, as in (4):

(4) σ

μ μ μ
 μ μ μ
 C V C

In the absence of a universal, inviolable constraint against trimoraic syllables, phonological theory provides (3a), (3b), and (4) as competing candidates for the representation of CVVC syllables. In the following section we examine phonological arguments for considering phrase-internal CVVC syllables¹ in Arabic to be bimoraic, rather than trimoraic, offering an account of cross-dialectal variation in Arabic syllable structures in terms of Optimality Theory. Then in section 3, we present phonetic evidence supporting the bimoraic analysis of CVVC syllables in Arabic. We argue that the durations of vowels and consonants in CVC and CVVC syllables produced by the Syrian and Lebanese speakers are consistent with the hypothesis that the vowel and the coda consonant in these syllables share a mora. In contrast, duration patterns for the Egyptian dialects are consistent with a shortening analysis, in which the vowel and the coda consonant are associated with separate moras. In section 4, we contrast Arabic durational patterns with those in Hindi, a language with a three-way distinction in syllable weight. We argue that Hindi CVVC syllables, in contrast to their counterparts in Arabic, show timing properties consistent with a trimoraic analysis.

2. The Phonology of CVVC Syllables

2.1 CVVC/CVCC Asymmetry

One major argument for assigning a bimoraic structure to CVVC syllables in Arabic involves the asymmetry between these syllables and CVCC syllables, which can be accounted for by assigning different

¹In this paper we restrict our attention to phrase-internal (actually, word-internal) syllables, assuming that different factors operate in phrase-final position.

moraic structures to the two syllable types. As noted by Broselow (1992) and Farwaneh (1992), a survey of Arabic dialects reveals that CVVC syllables are much more likely to surface phrase-internally than are CVCC syllables. CVVC syllables may be restructured by vowel shortening, as in the dialects of Lower Egypt (Broselow 1992), or by epenthesis of a vowel, as in Makkani Arabic (Abu-Mansour 1992). But in a majority of dialects, word-internal CVVC syllables are preserved intact:²

(5) CVVC Syllables

a. Shortening

Cairene, Alexandrian

kitaab+na -> kitabna

b. Epenthesis

Makkan

kitaab+na -> kitaabana

c. VVC preserved

Sudanese, Iraqi, Syrian, Lebanese, Gulf,

Upper Egypt³

k(i)raab+na -> k(i)raabna

CVVC syllables, on the other hand, are much more likely to be restructured through insertion of a vowel (where Δ represents the inserted vowel, while V represents a vowel that is present in this position in some dialects and not others; where present, it varies in quality across dialects):

(6) CVCC Syllables

a. Epenthesis

Cairene, Sudanese, Makkan

katabt+na -> katabt Δ na

Iraqi, Abu Dhabi

kVtabt+na -> kVtab Δ na

Others: epenthesis or preservation of CVCC, depending on quality of CC

The following chart, summarizing the surface occurrence of CVVC and CVCC syllables, makes clear that within a given dialect, CVCC syllables are more susceptible to restructuring than are CVVC syllables:

(7) Surface Word-internal CVVC, CVCC

	CVVC	CVCC
Cairene	no	no
Makkan	no	no
Sudanese	yes	no
Abu Dhabi	yes	no
Levantine	yes	only some CC clusters
other Gulf	yes	only some CC clusters

Farwaneh (1992) argues that in those dialects that permit CVCC syllables, the coda clusters that are permitted are generally those in which the first consonant is significantly more sonorous than the second. Since the situation is fairly complex, we will not for the purposes of this paper attempt to provide an account of the constraints permitting some CVCC syllables to surface in some dialects.

Thus far, we have found no dialect that allows CVCC but not CVVC. Broselow (1992) proposes to account for the asymmetry between CVVC and CVCC syllables as an effect of a prohibition on trimoraic syllables. CVVC syllables escape this prohibition because they are actually bimoraic, with the structure in (3a), in which the consonant shares a mora with the preceding vowel. CVCC syllables, on the other hand, are generally trimoraic (with the possible exception of those CVCC syllables permitted in particular dialects). We now turn our attention to how this analysis can be implemented within the framework of Optimality Theory, in which languages may differ in terms of their rankings of different output constraints.

2.2. A constraint-based analysis

Within the framework of Optimality Theory, surface configurations are accounted for by assuming that all possible candidates for pronouncing a given input form are evaluated with respect to a set of surface constraints. The form that best satisfies these constraints is the preferred form; where there is no form that satisfies all constraints, the form that satisfies the stronger (that is,

²The reader is referred to Broselow (1992) and Farwaneh (1992) for references on particular dialects.

³In some dialects, "book" is monosyllabic, as the parenthetization of the *i* indicates.

higher ranking) constraints wins. We propose to account for the asymmetric distribution of CVVC and CVCC syllables by assuming that all the dialects have two high-ranking constraints: (i) NO TRIMORAIC SYLLABLE, which forbids syllables dominating three moras; and (ii) PARSE SEGMENT, which forbids deletion of a vowel or consonant as a means of enforcing conformity to constraints on prosodic structure. Thus, the only acceptable structure for CVVC and CVCC syllables is a bimoraic one in which all segments are incorporated into prosodic structure and in which all coda consonants are dominated by a mora. We therefore need a set of constraints that will generate the appropriate bimoraic structures for each dialect.

The input form *k(i)taab+ha* will have two moras associated with the vowel of its second syllable, as shown in (8):

(8) input: $\begin{array}{c} \mu \mu \\ \vee \\ t a b \end{array}$

Assuming that trimoraic syllables and deletion of segments are ruled out, three possible surface analyses of this input form are as in (9):

(9) a. $\begin{array}{c} \sigma \\ \mu\mu \\ \vee \wedge \\ a b \end{array}$ b. $\begin{array}{c} \sigma \\ | \quad \backslash \\ \mu < \mu > \mu \\ \vee \quad | \\ a \quad b \end{array}$ c. $\begin{array}{c} \sigma \\ \wedge \\ \mu\mu \\ \vee \quad / \\ a \quad b \quad \Delta \end{array}$

(9a) corresponds to (3a), given earlier, and is consistent with the pronunciation found in Syrian, Lebanese, Sudanese and the majority of other dialects. (9b) involves a failure to incorporate the second mora of the long vowel into higher prosodic structure; the failure to parse this mora (indicated by angled brackets) will result in pronunciation of the vowel as short, as in Cairene and Alexandrian dialects. In (9c), a vowel has been inserted to provide a separate syllable for the /b/, resulting in the pronunciation found in Makkan Arabic. Before discussing the different rankings of constraints that will produce these three different surface configurations, we must deal with a fourth logical possibility, the structure in (3b), in which the /b/ is assigned to the coda but is not dominated by a mora. The surface form corresponding to this structure would be essentially the

same as that produced by the structure in (9a=3a). We have no phonological arguments to choose between (9a=3a) and (3b) at this point, and since the phonetic facts discussed in section 3 appear to favor (9a), we will assume that all the dialects also require that all coda consonants be moraic (via a constraint entitled No Appendix in Sherer (1994)).

We are now prepared to account for the dialectal variation in the treatment of word-internal CVVC sequences: Cairene and Alexandrian *kitaab+ha* -> *kitabha*, Makkan *kitaab+ha* -> *kitaabaha*, and all other dialects *k(i)taab+ha* -> *k(i)taabha*. We assume three additional constraints: a constraint against mora sharing No Branching Mora (= NBM); and the familiar constraints Parse Mora, which requires moras to be incorporated into higher prosodic structure, and Fill, which forbids insertion of new material into the string. The three patterns illustrated in (9) will result from different rankings of these constraints, where we adopt the precept of Optimality Theory that the form that satisfies the higher ranking constraint is the winning candidate. Ranking of NBM below Parse Mora and Fill will give the surface form in (9a), with vowel and consonant sharing a mora; the Syrian, Lebanese, and many other dialect forms satisfy the higher ranking constraints while violating the weaker NBM. Ranking of Parse Mora below Fill and NBM gives (9b), the Cairene/Alexandrian form, in which the least offending form leaves the second vowel mora out of the structure, resulting in a short vowel. And ranking of Fill below Parse Mora and NBM will give the Makkan form, (9c), in which a vowel is inserted (violating FILL) but the moraic structure of the long vowel remains intact (satisfying Parse Mora and NBM).

To assure that CVCC syllables cannot be assigned a bimoraic structure, we must rule out the assignment of a bimoraic structure to CVCC sequences; these generally undergo vowel epenthesis, in violation of Fill. Possible bimoraic analyses of these syllables are those shown in (10a) and (10b):

(10) a. $\begin{array}{c} \sigma \\ | \quad \backslash \\ \mu \quad \mu \\ \wedge \quad | \\ V C C \end{array}$ b. $\begin{array}{c} \sigma \\ | \quad \backslash \\ \mu \quad \mu \\ | \quad \wedge \\ V C C \end{array}$

(10a) can be ruled out by assuming a highly ranked constraint specifying that the head mora of a syllable—that is, the first mora—may dominate no more than one segment (NO BRANCHING HEAD-MORA=NBHM). This constraint would permit the mora sharing illustrated in (9a), where the nonhead mora dominates two segments, but not that in (10a). (10b) can be ruled out by a constraint forbidding mora sharing unless the segments sharing the mora maintain a particular sonority profile (with the required sonority distance varying across the dialects).⁴

Optimality Theory therefore makes possible an account of the distribution of CVVC and CVCC syllables across dialects. This account supposes a bimoraic analysis for CVVC syllables. We will now turn to the phonetics of these syllables.

3. The Phonetics of CVVC Syllables: Duration data

In this section we consider the match between the competing representations of Arabic CVVC syllable rhymes and the durations of segments in the syllable rhyme. One would expect the different structures (3a) and (4) to be associated with different timing patterns. Specifically, if the long vowel shares a mora with the following consonant, as in (3a), that vowel should be shorter than a long vowel followed by a heteromoraic consonant, but longer than a short vowel in a CVC syllable (2b). Similarly, a final consonant sharing a mora with a vowel, as in (3a), should be shorter than one with exclusive occupation of a mora, as in (2b).⁵ In contrast, we would not expect to find such a close relationship between vowel and consonant duration if the vowels and consonants have independent moraic structure, as in

⁴This analysis raises an interesting problem: the various constraints against branching moras cannot be combined, since they sometimes must be ranked differently with respect to other constraints. Thus, in dialects like Syrian, Lebanese, and Sudanese, which generally insert a vowel into CVCC sequences but maintain CVVC sequences intact, NBHM and NO CC MORA must be ranked above FILL to allow epenthesis in CVCC sequences, while the general constraint against branching moras (NBM) must be ranked below FILL to prevent epenthesis in CVVC.

⁵Note that the prediction of consonant shortening is crucial to the argument. Shortening of a long vowel in a closed syllable would not of itself argue for a difference in moraic association, since Closed Syllable Vowel Shortening is a common phonetic process (Maddieson 1985) that appears to operate independently of mora count and moraic association.

(2b) and (4). We will show data consistent with analyzing Syrian and Lebanese word-internal CVVC syllables as having the branching bimoraic structure in (3a): vowel and coda consonant durations are shorter than those in comparable CVV and CVC syllables, respectively, though vowels remain significantly longer than underlying short vowels. In contrast, underlying word-internal CVVC syllables in Cairene and Alexandrian were clearly restructured, resulting in the non-branching bimoraic structure in (3b).

3.1 Methods

Speakers of the four Arabic dialects—Alexandrian, Cairene, Syrian, and Lebanese—were recorded reading a list of words and sentences containing examples of CVVC syllables in word-internal and word-final position, plus CVC, CVV, and CV syllables in the same positions, for comparison. The lists were written in English, to avoid the possible influence of Arabic spelling on the speaker's pronunciation. Before recording, the speaker and experimenters reviewed the list together, to ensure that the speaker understood which Arabic word was intended by each English word on the list. To ensure that the speakers used colloquial Arabic, they were asked to translate into Arabic as they would speak with their friends. Subjects were carefully monitored for use of Modern Standard Arabic forms and were asked to redo any form they produced in Modern Standard Arabic as they would say it in casual conversation with a close friend. An example excerpt from the recording materials is given in Appendix I. Each speaker read through the full list three times, pausing for a brief break after each reading. In preparation for durational analysis, the tape recordings were then digitized on a PC using Kay Elemetrics' Computer Speech Lab (CSL) speech analysis system.

Durations were measured from wide-band spectrograms generated with the CSL system. Segmentation of the acoustic signal was made following common practice, in which the boundary between vowels and voiced consonants is taken to be the point at which formant amplitude changes dramatically—decreasing going from V to C and increasing going from C to V. For stop+vowel sequences, a stop burst, if visible, was taken to be the end of the stop. For the syllables containing voiceless aspirated stops (e.g., /t/ of *kitaabi*), the stop burst

was considered the end of the consonant, and the aspiration was measured as a separate element. For such cases, the onset of voicing for the vowel was then taken as the beginning of the vowel. In most cases, segmentation according to these principles was straightforward. Defining the boundary between two adjacent consonants (specifically, /bn/ of *kitaabna* and *Pinabna*) was sometimes more difficult, however, either because a /b/ release was not clearly visible, or because nasalization for the /n/ seemed to overlap the articulatory closure for the /b/. However, usually either /b/ release or onset of nasal formant structure for /n/ was visible and could be used as the criterion for segmentation.

3.2 Analysis

Since only one speaker of each dialect was recorded, duration measures were analyzed separately for each speaker. As illustrated in Appendix I, each of the words analyzed occurred in three different contexts, all of which involve phrase-final position. The segment durations for these three contexts were very similar, with no observable effects of sentence type, so for each speaker the nine duration measures (three repetitions x three sentence contexts) for each segment were averaged. The vowel and consonant averages are presented in the graphs in Figures 1-4. In these and all following graphs, the vertical "I" bars superimposed indicate the range of values one standard deviation above and below the mean duration.

Figures 1 and 2 show the results for the shortening dialects (Alexandrian and Cairene). We see that both speakers show the duration patterns predicted by the analysis in (9b). On the shortening analysis, the /a/ in *kitaabna* should be shorter than the /a/ in *kitaabi* (the phonologically long vowel) and similar in duration to the /a/ of *Pinabna* (the phonologically short vowel). For the Cairene speaker (Figure 2), the /a/ in *kitaabna* is 78.1 msec, about 40 msec shorter than the /a/ in *kitaabi*, and very close in duration to the /a/ in *Pinabna* (71.4 msec). For the Alexandrian speaker (Figure 1), the /a/ of *kitaabna* is very short (55.6 msec) less than half the duration of the long vowel in *kitaabi*, but also shorter than the phonologically short vowel in *Pinabna*. The consonant durations also pattern as predicted by the analysis. On the assumption that in both *kitaabna* and *Pinabna* the /b/ is associated with one mora, consonant durations for the two words

should be similar. For the Cairene speaker, the /b/ of *kitaabna* is 85.5 msec, versus 85.9 msec for /b/ of *Pinabna*; and for the Alexandrian speaker, the /b/ of *kitaabna* is 72.6 msec, compared with 83.7 msec for *Pinabna*.

To summarize so far, the duration patterns for the speakers of Egyptian Arabic are consistent with the shortening analysis proposed in (3b). Though the two speakers show differences in the absolute durations of the segments involved, the patterns of relative segment durations for each speaker behave as predicted. The only surprising result was the fact that, for the Cairene speaker, the /a/ in *kitaabna* was in fact shorter than the phonologically short vowel in *Pinabna*. This fact does not contradict the shortening analysis, but it does suggest that additional prosodic and phonetic factors not discussed here are also contributing to patterns in segment durations. Because we have only one speaker of each dialect, we can not say at the moment whether the difference in /b/ durations between our two Egyptian speakers represents a general difference between Cairene and Alexandrian or is due to idiosyncrasies of one or both speakers.

Figures 3 and 4 show the results for the CVVC-preserving dialects (Syrian and Lebanese). We see that both speakers show the duration patterns predicted by our analysis. Assuming that the CVVC syllable is bimoraic, without phonological vowel shortening, we proposed that the second mora associated with the syllable would be shared by the /a/ and the /b/, as in (9a). This predicts that the vowel of *kitaabna* will be shorter than a long vowel in an open syllable and longer than a short vowel in an open syllable. This is exactly what happens. For the Lebanese speaker, the vowel of *kitaabna* (97.8 msec) is shorter than the vowel of *kitaabi* (115.4 msec) and longer than the vowel of *Pinabna* (81.2 msec). For the Syrian speaker, the vowel of *kitaabna* is 112.2 msec, while the vowel of *kitaabi* is 123.9 msec, and the vowel of *Pinabna* is 65 msec. Our analysis also predicts that the coda consonant /b/ of *kitaabna* will be shorter than a coda consonant that has its own mora (*Pinabna*). Again, the duration data are consistent with our analysis. For the Lebanese speaker the /b/ of *kitaabna* is 66.7 msec, while the /b/ of *Pinabna* is 81.1 msec. For the Syrian speaker, the /b/ of *kitaabna* is 80.8 msec, while the /b/ of *Pinabna* is 114.4 msec.

Two-tailed t-tests were done to evaluate the significance of the duration comparisons discussed above. All of the differences in vowel

duration which we have attributed to differences in moraic association (e.g. /a(a)/ of *kitaabna* vs. *Pinabna* in Lebanese and Syrian) were significant, while vowel durations found to be similar, attributed to segments having the same moraic representation, were not found to be significantly different (vowel results significant to at least the .001 level). In addition, the very short /a/ of *kitaab+na* for the Alexandrian speaker was significantly shorter than the phonologically short vowel of *Pinab+na*. Though we do not yet have a definite explanation of this additional patterning, the important thing to note at this point is that it is consistent with a shortening analysis. For the consonants, the differences in consonant duration attributed to a difference between single-mora association vs. mora sharing (the coda /b/s in Lebanese and Syrian) were significant, and the durations of consonants associated with single moras (coda /b/s in Cairene and Alexandrian) were not significantly different (consonant results significant to at least the .01 level).

While the duration patterns of CVVC syllables in Lebanese and Syrian are consistent with our bimoraic mora-sharing analysis, the possibility remains that these syllables could be trimoraic, and the seemingly shorter durations of the vowel and the coda consonant are simply the natural consequence of accommodating more moras in one syllable. To rule out this possibility, we turn to another language, Hindi, for purposes of comparison.

4. Hindi

Hindi is one of several languages that have been reported to show a three-way contrast in syllable weight. Gupta (1987) and Pandey (1989) both argue that stress assignment in Hindi is sensitive to (at least) three degrees of syllable weight: light, heavy, and superheavy. According to Gupta (1987), stress is assigned to the heaviest syllable in a word (when equal, stress the leftmost).

- (11) Hindi
- | | | |
|----|------------|--------------|
| a. | ánuzanim | "internal" |
| b. | áandoolan | "movement" |
| c. | cinpáanjii | "chirpancee" |

So in example (11a), stress is assigned to the leftmost heavy syllable /an/, instead of the light syllable /ta/ or the heavy syllable

/rim/ to its right. Similarly, in (11b), the superheavy syllable /aan/ receives the stress, not the heavy syllable /doo/. Furthermore, (11c) shows the superheavy CVVC syllable /paan/ stressed, rather than the heavy syllables /cim/ or /jii/. Assuming that syllable weight is represented by mora count in the phonological structure, this three-way contrast in Hindi would require a trimoraic representation for superheavy CVVC syllables, as in (4), where the long vowel is associated with two moras, and the coda consonant with a separate mora.

To determine the duration patterns of these trimoraic CVVC syllables in Hindi, we recorded a Hindi speaker reading a list of words containing CVVC syllables in both word-internal and word-final positions, and, for comparison, CV, CVV, and CVC syllables in the same positions. Appendix II gives the Hindi words with their translations. Note that, for reasons mentioned earlier, the actual list used for the recording was written in English. The Hindi speaker read through the full list three times, and the tape recordings were then digitized and analyzed, using the same method described earlier. The results of segment durations for some of the words can be found in Figures 5 and 6.

Figure 5 shows the durations of the vowels and following consonants in word-internal position for four different types of syllables: CV, CVV, CVC, and CVVC. The long vowel /aa/ in the CVVC syllable (192.3 msec) is slightly more than twice as long as the short vowel /a/ in the CVC syllable (87.5 msec). The same durational contrast between long vowel /aa/ and short vowel /a/ can be observed in the open syllables (179.4 msec for /aa/ vs. 69.2 msec for /a/). These duration patterns are what would be expected if the long vowels have two moras and the short vowels have only one. They are also consistent with our trimoraic analysis for CVVC syllables in Hindi, where the long vowels are bimoraic. Similarly, the consonant durations are consistent with the analysis of CVVC syllables as trimoraic rather than bimoraic with sharing of a consonant and vowel mora. In Syrian and Lebanese, the consonant following a tautosyllabic long vowel was significantly shorter than a consonant following a tautosyllabic short vowel. In Hindi, coda consonants show no shortening after long vowels; in fact, the /l/ following the long vowel is actually longer than the /l/ following the short vowel: 122.9 msec

for the /l/ in *daaldaq* vs. 58.5 msec for the /l/ in *kalci*. The differences between the durations of the /l/s in *daaldaq* and *kalci* may be due in part to segmental differences between the word-medial clusters in the two items. In homorganic sonorant + voiced stop clusters in other languages, it is common for the sonorant to be quite long and the stop to be quite short. Thus, the /l/ in *daaldaq* may be especially long because it precedes a /d/. When we compare CVC/CVVC pairs in which the coda sonorant is followed by voiceless segments in both words, we find much closer consonant durations. Figure 6 shows the segment duration contrast for the words *parcai* and *paartii*. For vowel duration, just as we expect, the bimoraic /aa/ in /paar/ (186.4 msec) is a little more than twice as long as the monomoraic /a/ in /par/ (82.7 ms). The durations of the coda consonants are also as expected: /r/ in /paar/ (66.6 ms) is similar to, and certainly no shorter than /r/ in /par/ (59.1 ms). Thus the segment durations of both vowels and coda consonants in Hindi CVVC syllables are consistent with the trimoraic representation shown in (4), where the long vowel has two moras, the coda consonant has one, and no moras are shared.

These duration patterns of CVVC syllables in Hindi, as shown in Figures 5 and 6, are clearly different from those in Syrian and Lebanese (see Figures 3 and 4). If Hindi CVVC syllables show the duration patterns of true trimoraic syllables, then a different moraic representation is appropriate for CVVC syllables in Lebanese and Syrian. Given the durational patterns in these languages, the bimoraic mora-sharing representation in (9a) is the obvious candidate.

5. Conclusion

We have argued that a bimoraic analysis of Arabic CVVC syllables is justified both on phonological and phonetic grounds. A bimoraic analysis provides an account of the asymmetry between CVVC and CVCC in these dialects. And the phonetic facts of vowel and consonant duration are consistent with such an analysis: long vowels tend to be shorter in closed than in open syllables, and coda consonants tend to be shorter after long vowels than after short vowels; this is expected if long vowels and coda consonants share a mora. This analysis was confirmed by comparison with the durational facts of Hindi CVVC syllables. In Hindi, where there are independent phonological reasons for assuming a trimoraic analysis of CVVC

syllables, we found no shortening of either long vowels or coda consonants in these syllables. The Arabic and Hindi durational patterns therefore provide a reassuring match between the representations motivated by purely phonological considerations and the phonetic details of the utterance.

Appendix I

EXAMPLE OF MATERIALS USED IN RECORDING ARABIC

Subjects translated English phrases into their native dialect of Arabic, putting the words for book and grape in the position marked by underlining:

- (a) _____
 my _____
 our _____
 their _____
 And then I said "(a) _____"
 And then I said "my _____"
 And then I said "our _____"
 And then I said "their _____"
 And then I saw (a) _____
 And then I saw my _____
 And then I saw our _____
 And then I saw their _____

Appendix II

EXAMPLE OF HINDI WORDLIST

- | Hindi | gloss |
|-----------------|------------------------|
| 1. dāl | "group" |
| 2. dāal | "pulses" |
| 3. kālaa | "art" |
| 4. kālaa | "black" |
| 5. kālcī | "a ladle" |
| 6. dāaldāa | "vegetable shortening" |
| 7. adāalat | "court (of law)" |
| 8. vāardaāt | "event" |
| 9. párcāi | "shadow" |
| 10. páartii | "party" |
| 11. kámal | "lotus" |
| 12. káamal | "wonders" |
| 13. balāatkaar | "rape" |
| 14. carnāitkaar | "miracle" |

Fig. 1 Alexandrian

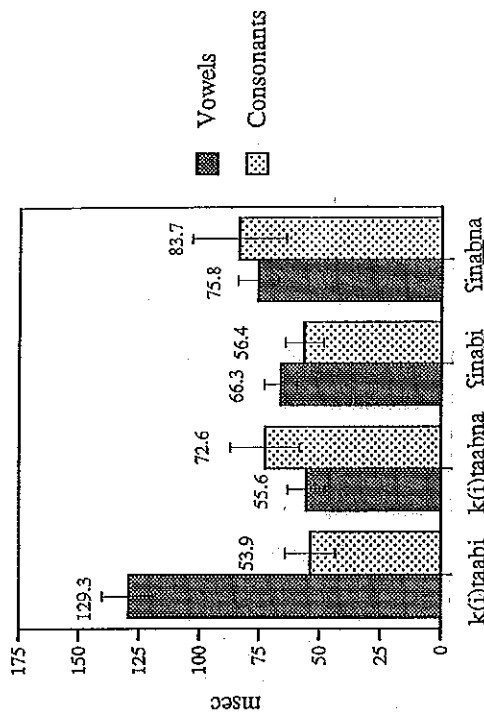


Fig. 2 Cairene

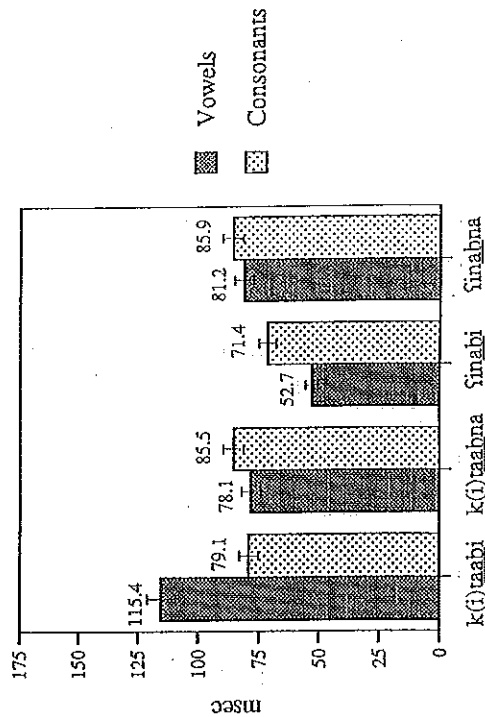


Fig. 3 Syrian

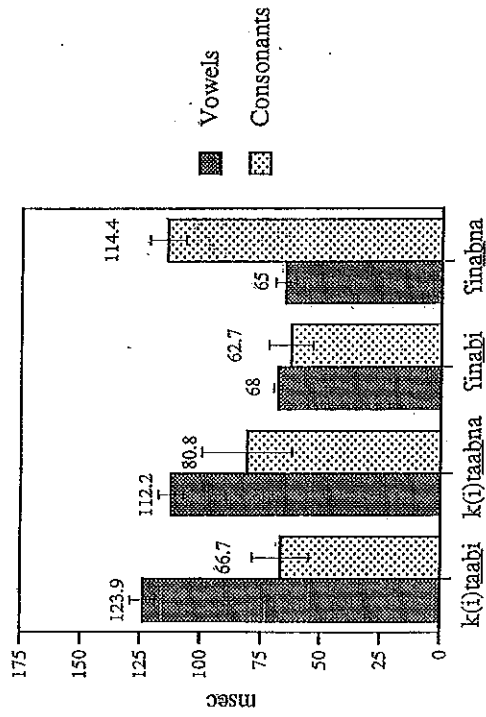


Fig. 4 Lebanese

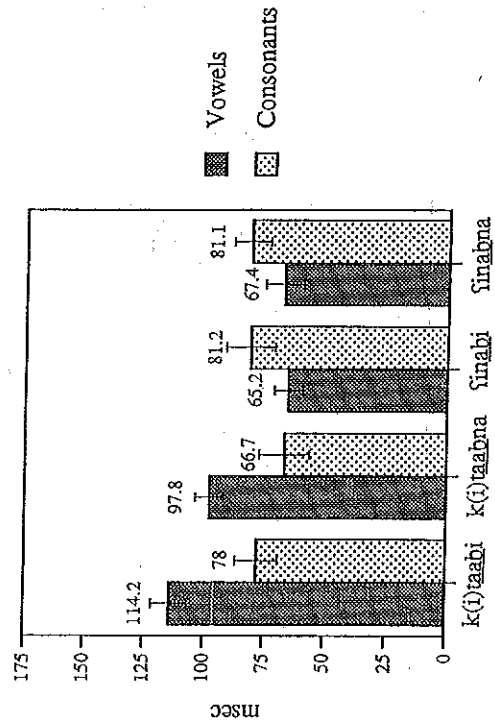


Fig. 5. V/C Duration Contrast in Hindi

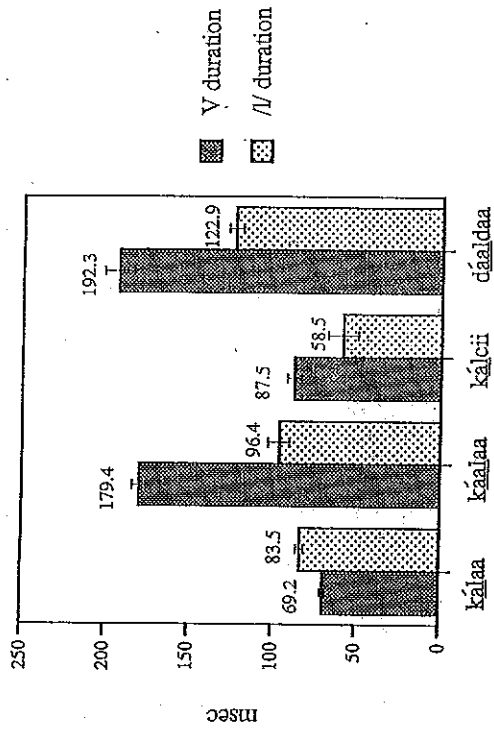
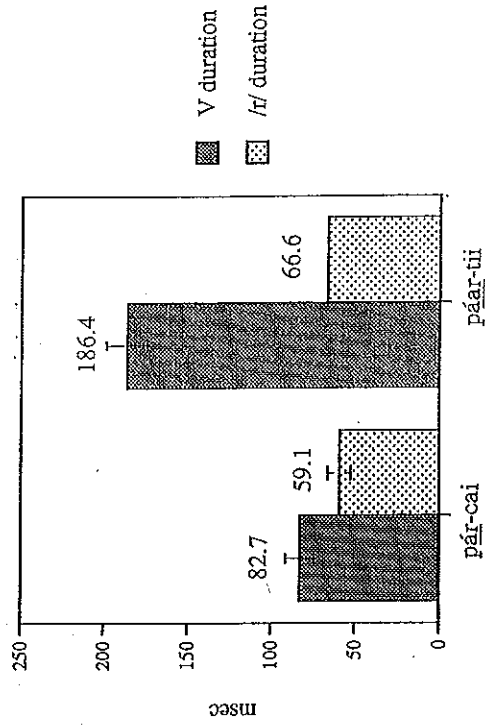


Fig. 6. CVC /CVVC Contrast in Hindi



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III

OTHER PERSPECTIVES