iere exists a rule that says that the numeral modifier must have the opposite gender of ie singular form of the plural noun it modifies. Thus, the feminine nouns *sayyaara* and *ıfs* take the masculine form of the numeral, the masculine *mataar* the feminine form of ie numeral -- a clear case of reverse gender agreement (or disagreement). But while this ımeral modifier must show gender agreement, the adjective modifier remains always conıant, regardless of the noun's gender. I suspect that this gender neutralization happens ecisely because the adjective here has no information about the gender of its noun: it ınnot tell whether *mataaraat* and *sayyaaraat* are masculine or feminine. This is not surising, since these nouns are made plural by the same morphological device, *-aat*. A simır thing can be said of the numeral modifier: it also is blind to the gender of the plural oun it modifies -- remember, it has to agree with the gender of the *singular* of the plural modifies. Now observe the following examples:

(21) θalaaθ maqaalaat tawiila
three-M articles long
'three long articles'

(22) θalaaθat maqaalaat tawiila
three-F articles long
'three long articles'

The nouns *maqaalaat* in (21) and (22) are identical. There is absolutely nothing in em to clue us into the nature of their gender. All we know about them is that they are the plural form because of the suffix *-aat*, and their identical adjectives (Adj 2) reflect is fact by the mere fact of their (the adjectives') identity. However, *maqaalaat* in (21) is e plural of *maqaala*, in (22) *maqaalaat* is the plural of *maqaal*. This we know from the nder of the accompanying numerals. Without the presence of these numerals we would ve no information about the gender of the singular forms of *maqaalaat* in either (21) or 2).

But what of the numeral? To choose the appropriate form of the numeral, we ve to convert the plural noun into its singular, determine its gender, choose the converse nder of the singular, and then use it with the plural noun. This, I claim, is a highly mplex and conscious process of lexical decomposition, viz., decomposing the plural noun its singular form, then determining its proper gender. (21) and (22) refute any claim iose purpose is to assert the automaticity of this process, for one must know first which the two singular nouns that *maqaalaat* is the plural of before the appropriate numeral n be determined.

To recapitulate, we have seen how the numeral modifier agrees with the noun it odifies: it agrees, of course, in number, i.e., with a quantity of three or more, and it rees in gender (by a complex, and maybe artificial, process of reverse agreement). owever, the adjective (Adj2) defies any agreement in gender as it stays constant regards of the gender of the plural noun's singular. A clear implication of the latter part of s paper is that the neutralization of gender in Adj2 is the direct reflection of the gender ıtralization in plural non-human nouns themselves. Adj2, it was claimed, encodes num-, and it is claimed that this agreement is semantic *because* Adj2 remains constant with plural non-human nouns, regardless of the noun's morpho-phonological makeup. This t reason has led us to postulate that Adj1 and Adj2, though identical in form, are differ- in their semantic content and, thus, function.

Colorado Research in Linguistics 11

ONSET-RHYME TEMPORAL STRUCTURE OF MANDARIN SYLLABLES

ALAN BELL AND MEICHUN LIU*

Introduction. This is a preliminary report on some timing relationships of Mandarin Chinese syllables. It was originally stimulated by an assertion by Ou Yan (1980) that the rhyme of Chinese syllables did not vary in duration when various segmental factors were changed, particularly when a final nasal was added to a syllable, or if diphthongal rhymes were compared to monophthongal ones[1]. Because Chinese is a tone language in which most syllables are pronounced with one of four tones, and because the tones have traditionally been associated with rhymes of syllables, the hypothesis has a certain plausibility, for example, if it were the consequence of inherent duration of each tone imposing itself upon the articulatory program of rhyme components. Although there have been numerous studies of Mandarin Chinese duration, none have addressed this issue with data of sufficient scope and quality. Our goal was to examine the durational interaction of combining different onsets, nuclei, and codas in Mandarin Chinese under comparable conditions. We did not consider phrase-positional effects, and considered the effects of different tones only to a limited extent.

What follows is a slightly expanded and revised version of a paper presented at the meeting of the Acoustical Society of America at State College, Pennsylvania on May 23, 1990. It is based on data from four speakers at a normal rate of speech. The full data set, which we are continuing to analyze, consists of data from six speakers at normal and fast rates of speech. The present partial data is nevertheless sufficient to reveal a general picture and some details of the internal temporal relationships among the components of the Mandarin syllable.

Let us first quickly review the structure of Mandarin syllables. Since there are no consonant clusters in Mandarin, onsets are all simple consonants, except for affricates. There are four simple vowels, but a wealth of diverse diphthongs. The only consonants that can close a syllable are the nasals **n** and **ŋ**. Except for the so-called neutral syllables, a syllable is pronounced with one of four tones.

The Data. Our data was collected and analyzed in the following way. Each experiment is based on a small number of syllables, all of which were real words. While Chinese speakers are perfectly able to pronounce combinations of tones and segments that are possible syllables but not actual words -- by changing the tone of a real word, for example -- we found in pilot experiments that speakers often hesitated before some items of this sort (or even before words that were somewhat unfamiliar), upsetting the smooth rhythm of their chosen speech tempo. The words for each experiment were arranged in nine randomly ordered lists. Except for Experiment 3, the lists were divided in half. Two dummy syllables were added to the beginning and the end of each list or half-list. (In Experiment 4, dummy syllables were also added between each target word to break up the repetition of syllables beginning with **t**.) The speakers thus read one list or half-list at a time, each consisting of words written in Chinese characters.

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The speakers pronounced the words in the frame *Wǒ tjúe de ___ bù nán xiě*, which means 'I feel that ___ is not difficult to write' at a normal rate of speech. Before recording, each speaker practiced reading through the lists until they and the experimenter were comfortable that they were at ease with the task. The present data was recorded by two men and women, all in their late 20s or early 30s, all of whom grew up and lived most of their lives in Beijing.

The recorded sentences were converted to digital form. Durations were measured using a locally developed waveform analyzer. The syllable onset was measured from the closure of the initial consonant to its release. The rhyme was measured from this release to either the closure of the following labial stop or to point where there was no longer any apparent higher frequency intensity. The rhyme thus included any stop aspiration, if present. Syllable duration was the sum of the onset and rhyme durations. One criterion for the choice of the frame and onset segments was that they provide consistent and clear acoustic indications of onset and release -- for most points, the uncertainty was 5 msec or less. The measured durations appeared to be stable with few outliers. Standard deviations of onset durations pooled over subjects varied from 12 to 17 msec; of rhymes, 14 to 19 msec; and of the entire syllable, 18 to 24 msec. The results that follow are based on the complete set of observations -- there are no missing or excluded observations.

Experiment 1 -- Initial Consonants. Syllables with different onsets, vowels, and tones are compared in Experiment 1. The focus is on the effect of initial consonants of different durations.[2] Examining the effect of onsets is important in order to contrast the role of the rhyme with that of the syllable as possible domains of temporal regulation; one cannot conclude that the rhyme is the timing unit of the syllable until the syllable itself can be eliminated as a candidate. Thus syllables in Experiment 1 began with one of four consonants -- **n**, **t**, **tʂ**, or **ʂ**, from shortest duration to longest. The stop and affricate **t** and **tʂ** are phonologically unaspirated (phonetically, there usually is a short period of voicelessness after the release of **t**) and **tʂ** and **ʂ** are retroflex sibilants. These onsets combine with the vowels **a** and **u** and with the rising tone and the falling tone to make up the 16 syllables examined in Experiment 1:

Colorado Research in Linguistics, Vol. 11 [1990]

	rising tone		
na	**ta**	**tʂa**	**ʂa**
nu	**tu**	**tʂu**	**ʂu**
	falling tone		
na	**ta**	**tʂa**	**ʂa**
nu	**tu**	**tʂu**	**ʂu**

Experiment 1 -- Results. Most of the results that we report are highly significant, with p less than .001, based on a repeated measures analysis of variance over the observations averaged over subjects. Henceforth we do not indicate the individual significance of results unless they are 0.001 or above; effects are consistent over subjects unless otherwise stated.

Syllables with a rising tone were 25 msec longer than those with a falling tone. (Rhyme durations averaged 27 msec longer, and onset durations were unaffected by tone.) The results presented in Figure 1 are durations averaged over the two tones.[3] In the schematic summary of Figure 1, the single lines represent the consonant onset durations and the open boxes the durations of the vowels.

Figure 1. Durations of onsets and rhymes for the syllables in experiment 1.

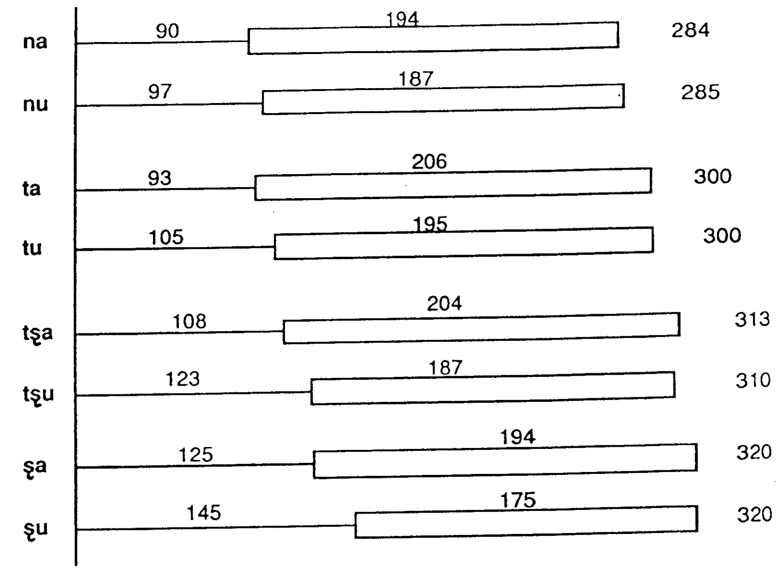
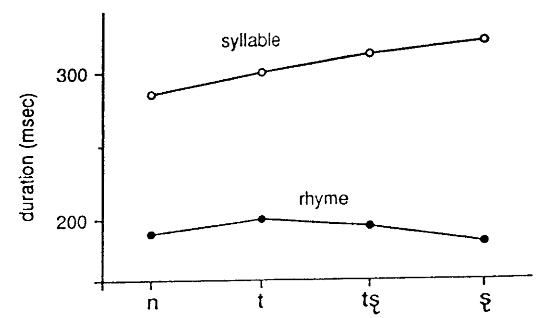


Figure 2. Rhyme and syllable durations for different onsets.



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We ask first whether longer onsets produce longer syllables. Examining the onset airs in Figure 1 from top (**n**, the shortest consonant) to bottom (**ʂ**, the longest one), we ee that they do. Syllables beginning with **ʂ** are about 35 msec longer than syllables beginning with **n**, the others falling in between, with all individual differences significant.

Now, comparing the pairs of syllables ending in **a** and **u** for each initial consonant, e note first that, as expected, the low vowel **a** is longer than the high vowel **u**, by an avrage of 14 msec.[4] In contrast to the initial consonant, however, syllable duration is unafected by the vowel. This is because all four onset durations vary inversely with the rhyme urations, compensating almost exactly for the difference in vowel length. (The almost exct correspondence here is indeed revealed by the subsequent experiments to be a bit too ood to be true.)

The effect of different onsets on rhyme and syllable duration is compared more losely in Figure 2, where durations are pooled over the two vowels. All the individual diferences are significant except for the **n** and **tʂ** rhymes.[5] Whereas syllable duration increases significantly for each longer consonant, the rhyme duration differences are not so mple. Syllables beginning with **n** excluded, there appears to be an inverse decrease in hyme duration of about one-half the magnitude of the increase in syllable duration. Rhymes after **ʂ** average 16 msec shorter than after **t**, leaving 20 msec of the 36 msec onet duration difference between **t** and **ʂ** to show up as a difference in syllable duration.) uch a neat picture of inverse variation of syllable and rhyme is probably illusory, however, nce rhymes following **n** are shorter, not longer than following **t**, so there cannot be a eneral linear decreasing relationship of rhyme durations from shorter to longer onsets. Ve return to this point in the concluding general discussion.

To sum up the results of experiment 1, syllable durations are longer after longer onets, but are not affected by the difference in the duration of the vowels **a** and **u**. Rhyme urations are shorter after the longer obstruent onsets, and of course vary directly with owel duration.

xperiment 2 -- Monophthongs and Diphthongs. Experiment 2 focuses on the effects of ifferent nuclei. All the syllables in this experiment have falling tone, and there are only wo onsets for each vowel, a stop and a sibilant. Three monophthongs. **a, i,** and **u**, are ompared with the three diphthongs **ai, au,** and **ou**. The inventory of syllables for xperiment 2 is thus

		falling tone			
ta	ti	tu	tai	tau	tou
ʂa	ɕi	ʂu	ʂai	ʂau	ʂou

ote that since ***ʂi** is not a permitted combination in Mandarin Chinese, the palatalized bilant **ɕ** was used instead of the retroflex sibilant before **i**.

Experiment 2 -- Results. The durations for the syllables of Experiment 2 are disayed in Figure 3. As we would expect from Experiment 1, **ʂ** is longer than **t** (by an avage of 27 msec). The palatalized sibilant **ɕ** before **i** is even longer, however, 61 msec nger than **t**, so that the **ti-ɕi** pair of syllables is apparently not directly comparable to the her five pairs. It is thus omitted in the comparisons that follow. We again find that onts affect syllable and rhyme durations. Syllables beginning with **ʂ** average 11 msec longer an syllables with **t**. Conversely, the rhyme is on the average 21 msec shorter after the nger **ʂ** than after **t**.

Figure 3. Durations of onsets and rhymes for the syllables in Experiment 2.

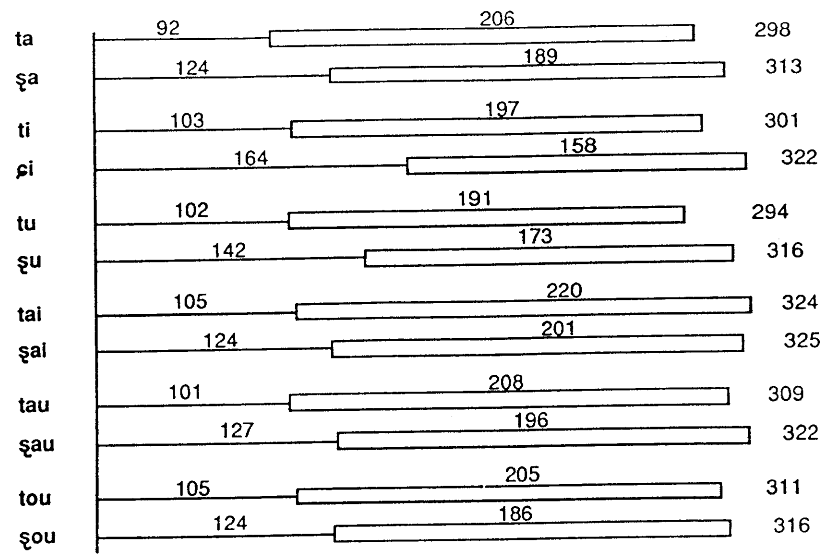
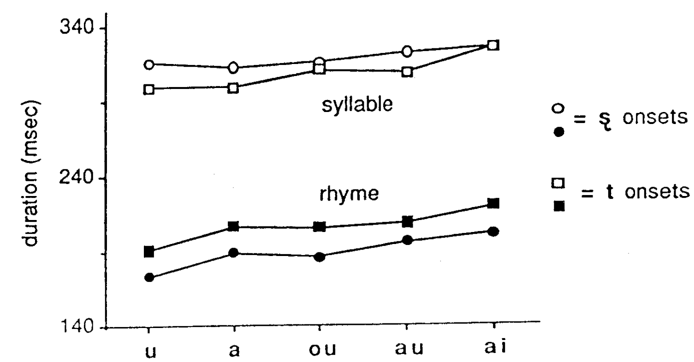


Figure 4. Rhyme and syllable durations for monophthongs and diphthongs.



Now let us examine Figure 4 to see the effects that different nuclei have on rhyme and syllable durations. Although the durations are plotted separately for **t** syllables and for **ʂ** syllables, there is no significant onset x vowel interaction, so we can consider the overall vowel effects. The rhyme durations do vary. As in Experiment 1, the low vowel **a** is significantly longer than the high vowel **u**, by 16 msec.[6] The diphthong **ai** is longer than **a** by 13 msec, and 8 msec longer than **au**.[7] The vowel **a** and the diphthongs **au** and **ou** do not differ significantly. It is not surprising that **ai** is the longest diphthong, since phonetically it has the greatest change in vowel quality.[8] Nevertheless, these small differences clearly do not support timing models which, in accord with the transcription, incorporate two vowel units for diphthongs versus one unit for simple vowels.

Syllable durations show little variation. Of the diphthongal syllables, only the **ai** syllables are clearly longer than **a** syllables, by 19 msec. (The syllable duration of **tai** may be anomalously high, however, so this result should be regarded with caution until it can be confirmed by further analysis and additional data.)[9] Note that while there appears to be some sort of compensation in the length of the onsets before **a** and **u**, so that syllable durations are much the same even though the vowels are different, nothing of the sort appears to occur for the diphthongs.

Experiment 3 -- Final Nasals. Experiment 3 compares four syllables with no coda with four syllables closed by the consonant **n**:

	falling tone		
ta	**tu**	**ʂa**	**ʂu**
tan	**tun**	**ʂan**	**ʂun**

All of the syllables were pronounced with falling tone.

Experiment 3 -- Results. From the schema of durations in Figure 5, it is obvious that open syllables are shorter than syllables closed by **n**. Figure 6 shows the syllable durations in a little more detail. Not only are nasal syllables longer (by an average of 28 msec), their syllable durations behave **just** like open syllables with respect to the vowel and initial consonant. That is, we find essentially the same effects as in the first two experiments: Syllables beginning with **ʂ** are 14 msec longer than those with **t**, and there is a small (10 msec average) lengthening of syllables with **a** compared to syllables with **u** ($p = .003$).

The rhymes of syllables ending in a nasal are almost exactly as much longer (30 msec average) as the syllable durations themselves. Obviously this implies that there is no shortening of onsets before the longer nasal rhymes, unlike the shorter onsets that we have consistently found before the longer low vowel **a** compared to the high vowels **u** and **i**. And this difference holds even though the nasal-oral duration difference of 30 msec is longer than the **a-u** difference of about 15 msec. (Similarly, note that onsets in Experiment 2 were no shorter before **ai** than before **a**.)

The durations of final nasals are displayed in Figure 7. Nasals are in general longer after **u** than after **a**, by an average of 15 msec. The longer (by 8 msec) nasals after **ta** than after **ʂa** are entirely due to one speaker.

Experiment 4 -- High Vowel Diphthongs. Experiment 4 examines the durational structure of syllables with the high vowel diphthongs **ia** and **iau**, and the diphthong-nasal combination **ian**. These rhymes are compared with the simple vowel rhymes **i** and **a**, the diphthong

Figure 5. Durations of onsets, rhymes, and nasal codas for the syllables in experiment 3

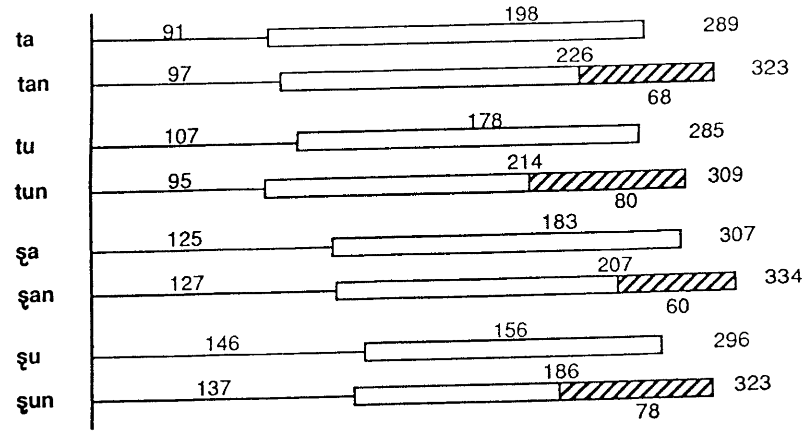


Figure 6. Syllable durations for oral and nasal syllables.

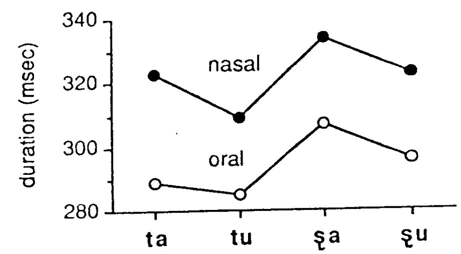
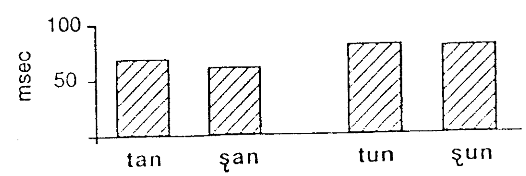


Figure 7. Durations of final nasals.



au, and the nasal rhymes **an**, **aŋ**, and **iŋ**. All the syllables begin with the onset **t** and have high tone.

	high tone	
ta	**tan**	**taŋ**
ti		**tiŋ**
tau		
tia	**tian**	
tiau		

Experiment 4 -- Results. We examine first the durations of the oral syllables, which are displayed schematically in Figure 8. There is no significant difference between the onset, rhyme, and syllable durations of **ta**, **ti**, and **tau**, nor between the durations of **tia** and **tiau**. But the durations for **tia** and **tiau** are significantly different than those for **ta**, **ti**, and **tau**. Onsets before **ia** and **iau**) are 7 msec shorter than before **i**, **a**, and **au**;[10] **ia(u)** rhymes are 27 msec longer than those for **i**, **a**, and **au**. The difference in syllable duration is thus 20 msec. The onset effect, though small, is still significant if we compare **ti** (whose onset duration averages 110 msec) to **tia** and **tiau** (average onset duration of 102 msec)[11].

The nasal syllable durations are compared to the durations of the oral syllables in Figure 9. The results confirm those from Experiment 3. Nasal syllables are longer than oral ones by an average of 27 msec, nasal rhymes are longer by 29 msec, and there is no significant shortening of onsets before the longer nasal rhymes. The syllable **tian** has the longest duration of any syllable in the study, because of the nearly additive (or multiplicative) combination of the effects of the high-low diphthong and of the nasal coda.

Conclusions. The results of our experiments show that both rhyme and syllable durations vary with respect to all components of the syllable -- tone, initial consonant, vowel, and the presence of a final nasal. So the question is not whether these units are temporally invariant, but rather how much they vary and in what ways. The strongest effects on rhyme and syllable durations are summarized in Table 1.

Table 1. Differences in the duration of rhymes and syllables with respect to tones, initial consonants, nuclei, and final consonants. Values are rounded to the nearest 5 msec. See text for a descriptions of the data on which the values are based.

	Rising vs falling	**ʂ** vs **t**	**a** vs **u**	**ia & iau** vs other	nasal vs open
Rhyme	+25	−20	+20	+25	+30
Syllable	+25	+15	+ 5	+20	+30

The **a-u** and **ʂ-t** comparisons are chosen because data on them is available from the first three experiments, and the values here are composite ones from the comparison of **ta**, **tu**, **sa**, and **su** in those experiments. The tone comparison is from Experiment 1 (falling vs. rising tone), the high vowel diphthong comparison from Experiment 4, and the nasal coda comparison from Experiment 3. All of these differences are highly significant, with $p < .001$, except for the small difference in **a** and **u** syllable durations.[12]

Some of these results parallel those found by Ren (1985, 1986) in studies of Mandarin segment durations[13]. They disagree in some respects with those reported by Svantesson (1984) for vowels, diphthongs, and vowel-nasal sequences, however[14].

Figure 8. Durations of onsets and rhymes for the open syllables in experiment 4.

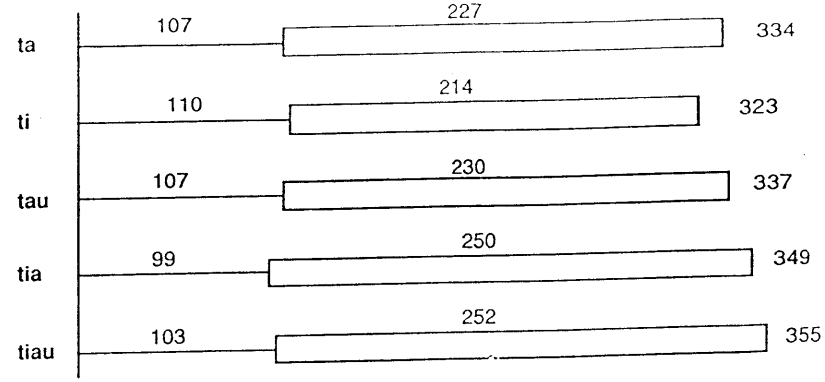
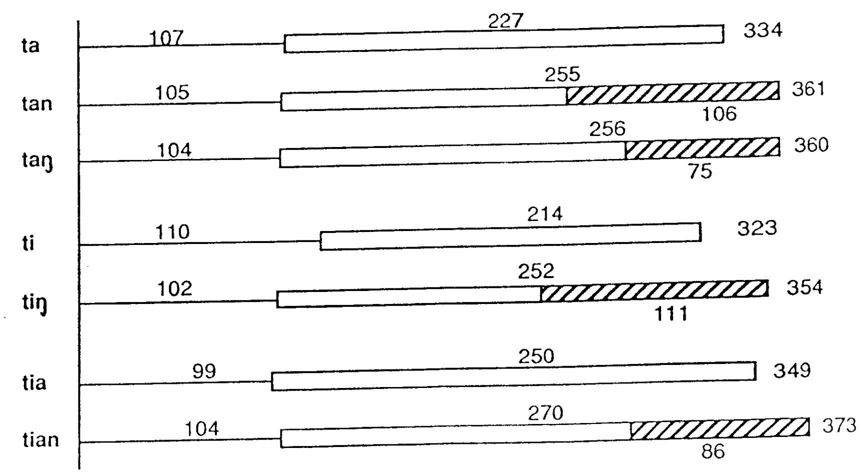


Figure 9. Comparison of the durations of open and nasal syllables.



Note that these differences are all in the directions that we would expect from universal tendencies: rising tones are generally longer than falling tones[15], sibilants longer than stops[16], low vowels longer than high vowels[17], diphthongs longer than simple vowels[18], and VN sequences longer than simple V[19]. Moreover, the relative magnitudes, which range from about 17 per cent for the rhyme and from about 9 per cent for the syllable down to 5 per cent or less, are below the amount that has been estimated as the JND for speech segments in context (Klatt & Cooper 1975). In this regard, Xu and Whalen (1990) found that the small intrinsic duration differences between Mandarin tones do not appear to provide an effective perceptual cue. The small magnitudes of the rhyme and syllable duration differences, then, appear to justify the claim that the rhyme and syllable are **perceptually** temporally invariant in Mandarin Chinese[20].

These results, however, do not necessarily point to the rhyme as the locus of invariance. Both the rhyme and the syllable are lengthened equally by longer tones, addition of a nasal coda, and the presence of high vowel diphthongs, which are the largest effects, because onset duration is little affected by these differences. Longer onsets themselves would, if the rhyme were truly invariant, directly result in longer syllables. But in fact the rhyme 'absorbs' some of the duration of longer onsets, so that the effect on the syllable is mitigated. Conversely, onsets 'absorb' some of the effect of longer vowels, so that the effect of vowel duration differences on the syllable is reduced. These relations suggest that the syllable has stronger claim than the rhyme as an invariant unit of duration.

We next need to consider whether the Mandarin syllable (or rhyme) can be considered a timing unit in the sense that the timing of segmental gestures is at least in part organized at the syllabic level in such a way to maintain equivalent syllable durations. There are two kinds of compensation in segmental durations that one would expect to find in this case. One, which we do not consider here, is compensation for variation in segment durations from token to token, e.g. longer than average stop closures followed by appropriately shorter vowel durations. The other is compensation for the variation in intrinsic durations of different segment types. Of course not all such compensation can be taken as support for the syllable as a timing unit. Such compensation should be of the appropriate magnitude to maintain the durational invariance of the syllable, and should show evidence of being a language-specific temporal adjustment compatible with a temporally invariant syllable.

The interactions between the onset and the following vowel that we observed do not appear to meet these criteria. While the shorter onsets before **a** than before **u** are of roughly the right magnitude to maintain temporal invariance of the syllable, but that does not appear to be the motivation for this interaction. Instead, it is probably the lowness of **a** rather than its length that accounts for the shorter onsets. The same effect was found in French by O'Shaughnessy (1981), who attributed it to the difference in physiological constraints between obstruent + high vowel sequences and obstruent + low vowel ones. It also turns up in the Japanese data of Port et al (1980) and Port et al (1987)[21]. Furthermore, if this were a syllable-level duration compensation, then we would expect to find shorter onsets before longer rhymes of the same vowel height. There are four situations in our data where this could have happened. In three it clearly did not. Longer rising tones or high tones did not have shorter onsets than the shorter falling tones. The longer diphthong **ai** did not have shorter onsets than **a**. The longer nasal rhymes did not have shorter onsets than the plain rhymes with the same vowel. Recall, however, that for three speakers the **t** closures were slightly shorter by 8 msec before the longer diphthongs in **tia** and **tiau** than in **ti**. (It is of course possible that either a somewhat lower vowel height at the onset of **ia** and **iau** or a difference in their tongue trajectory may be the responsible factor here.)

The shortened vowels after longer fricatives and affricates can possibly also be attributed to local constraint differences between fricative + vowel and stop + vowel sequences. Crystal and House (1988a) found that American English vowels were longer after stops than after fricatives (and nasals and laterals) by about 20 per cent; O'Shaughnessy (1981) also found the same effect in French. (Unlike Crystal and House, he included aspiration in his vowel durations, which may have inflated the effect.) Note that while the apparent duration compensation of the vowel holds between stop and continuant onsets in our data, it did not hold between nasal and oral stops in Experiment 1.

Nasal durations offer a final potential case of duration compensation. The shorter nasal in **ʂan** compared to **tan** (Figure 7) might be attributed to a global mechanism of temporal compensation. Because of the small magnitude of this effect and its failure to appear in the **ʂun-tun** syllables, we withhold judgement on this case until the full data set can be examined. In Experiment 4, the final nasal **ŋ** is shorter after **a** in **taŋ** than after **i** in **tiŋ**, and the nasal **n** is shorter after **ia** in **tian** than after **a** in **tan** (Figure 9). The durations of **ŋ** are explainable in terms of the height of the vowels, rather than their duration, just like the onset differences before **a** and **u**. (Compare **na** and **nu** in Figure 1.) The differences in the durations of **n**, however, cannot be explained in this way, since **tian** is phonetically [tien], ending in a higher vowel than **tan**, yet nevertheless having a shorter nasal duration[22].

Overall, then, we are able to find little compelling evidence from segment compensations for an invariant syllable timing unit. The onset-rhyme interactions seem to be of a local and universal nature; some of the vowel-nasal coda interactions may turn out to require a global explanation. We cannot rule out a mechanism of syllable timing as part of the overall temporal structure of Mandarin Chinese, but the evidence so far indicates that the Mandarin syllable is predominantly locally organized.

This still leaves unanswered the question of why Mandarin syllables of different structures vary so little in duration. This very question presupposes that the relative invariance is a language-specific phenomenon, and not an expected outcome of universal processes. Is this really so? We remarked above that the direction of the differences in rhyme and syllable duration summarized in Table 1 all match universal tendencies. What about the magnitudes? Answering this question is a major challenge, given the relatively few careful studies of duration that are available and the hazards of comparing results based on very different kinds of data. Although a careful answer is beyond the scope of this paper, we have made a preliminary assessment based on the sources most readily available to us.

Based on the sources mentioned in note 16, the usual difference in the duration of high versus low vowels is about the same as in Mandarin, i.e. roughly 10 per cent. A few languages show larger differences. Choi (1990) reports that Kabardian mid **e** is about 45 per cent longer than high **i**; in the Japanese data reported by Port et al (1980) and Port et al (1987) short **a** is about 25 per cent longer than short **u**. A number of languages appear to show larger differences between sibilants and stop closures than the 35 per cent that we find in Mandarin (note 15).

The very small lengthening that we find for **ai** and **au** is comparable to Cairo Arabic and Thai diphthongs, but much less than that found in English and Hausa (note 17). The somewhat greater lengthening of the Mandarin **ia** and **iau** nuclei also appears to be quite modest. In the absence of sufficient comparative data, we surmise that there are both languages in which VN sequences are similar in duration to plain Vs, and languages in which VN is substantially longer, as for example French (note 18). One reason to think that Mandarin Chinese falls in the first group is that many Mandarin speakers vary be-

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tween vowel + nasal and a nasalized vowel alone. (In our focused context, however, we observed only one token without nasal closure.)

The overall picture of Mandarin is that its differences in inherent segment durations appear in all cases to be in the lower range of durations found in other languages. The relatively invariant durations of Mandarin syllables and rhymes seems to result from a combination of lack of large segment duration differences and segment-to-segment compensations of the sorts and magnitudes to be expected on universal phonetic grounds. There neither appears to be any need for a macro timing mechanism above the segment to maintain invariance nor any compelling evidence from segment compensation that there is one. One can regard this situation as an accident -- that is, Chinese neither inherited large segment differences nor has it happened to phonologize and exaggerate the existing phonetically motivated ones. In view of the failure for this to happen in any of the variety of possible cases discussed above, we should at least question the accidental explanation very carefully. (Note, in addition, that Chinese affricates are about the same duration as single stops and fricatives, and that even tone duration differences do not seem to be very great except in citation forms.) One hypothesis that should be entertained is that speakers have internalized a generalization of quasi-invariant syllable duration (or rhyme duration, or both) that has inhibited phonological exaggerations of segment duration differences that would conflict with it. Typically, we look for functional or contextual factors that may promote certain sorts of changes, but here we may have an inhibitory factor strong enough to predominate over any facilitating ones.

Notes

[1]Ou Yan does not cite any experimental data. Woo 1972, on the basis of (apparently) single repetitions of words spoken in isolation, draws the same conclusion. Sventsson's 1984 data of better quality (four speakers, two repetitions of words in sentence frames) does not support this conjecture. His results are discussed further below in note 13.

[2]We did not include syllables with no onset, since pilot studies showed that in the contexts we used, they were pronounced with a clear glottal stop whose closure duration was about the same as other stops. Chao 1968 mentions this as a feature of a 'minority' of speakers.

[3]The only significant tone interaction was the small vowel x tone effect for rhyme duration ($p = .02$), noted below.

[4]This difference was 6 msec smaller for rising tone than for falling tone (11 msec vs 17 msec), an effect found in three of the four speakers.

[5]The significance level of the **t-tş** rhyme difference is $p = .004$.

[6]Considering only the syllables beginning with **t**, the vowel **a** is also longer than **i**, by 10 msec, $p = .004$.

[7]The significance level of the latter difference is $p = .007$, and the effect was limited to two speakers.

[8]Lindau et al 1985 report that **ai** has an acoustic distance 1.32 times that of **au** and 1.95 times that of **ou**.

[9]For two subjects, **au** syllables are also longer than **a** syllables.

[10]The onset effect significance was .005, and limited to three speakers; their onsets were 10 to 11 msec shorter before the **i**-diphthongs.

[11]According to the formant measurements of Svantesson 1984, the **i**- component of **ia** and **iau** is slightly higher than monophthongal **i** (F_1 = 395 Hz versus 259 Hz). Preliminary measurements of F_1 for one of our speakers did not show any significant difference, however.

[12]While its overall significance is $p = .005$, the difference is due entirely to two of the speakers. For the other two speakers, the shorter onsets before **a** almost or entirely compensated for its longer duration.

[13]Ren's studies were also based on pronunciations of single words in a constant sentence frame, but his data contained more words (115 or so), more subjects (eight), and fewer repetitions (only one of each word); the measurements were made from 10 cm/sec oscillographic traces. While he does not report measurements of whole syllables, his vowel measurements are consistent with some of our results: the vowel of high tone syllables 1.06 times longer than that of falling tone syllables (data from 13 words, $p < .05$); **a** 1.09 times longer than **i** and **u** after **t-** (data pooled over 4 tones, $p < .05$); **iau** slightly longer (325 msec) than **ai** (312 msec) and **au** (308 msec); and **a** about 1.11 times longer after **t** than after **s** and **ts** (data pooled over 4 tones, $p < .05$ for **s**, $p < .1$ for **ts**); **-an** 1.09 times longer than **-a** (durations estimated from his Figure 4).

[14]Svantesson's data is based on spectrographic measurements of high tone words in a sentence frame repeated twice by four speakers. He finds that **a** is 1.05 times longer than the average of **u** and **i**, much the same as our ratio of 1.11, but the difference is due entirely to the shorter **u**; **i** is actually 6 msec longer than **a**. The diphthongs **ou**, **au**, and **i** average 1.18 times longer than **a**, and have different relative durations than we found (**au** is longest, 226 msec compared to **ou**, 195 msec, and **ai**, 185 msec). The nasal rhymes **an** and **un** average 1.51 times longer (71 msec) than **a** and **u**. (Svantesson's speakers appear to have much longer nasals than ours, 57 per cent of the coda, compared to our 34 per cent.) The diphthongs **ia** and **iau** are 1.33 times (57 msec) longer than the duration of **a**. In fact, Svantesson's absolute durations of **au**, **ia**, **iau**, and **ian** are quite similar to our Experiment 4 values with high tone syllables, but his duration of **a**, 171 msec, is much shorter than our 227 msec. We presume that some aspect of the data elicitation lies behind the discrepancy between Svantesson's results and Ren's and ours.

[15]The relatively little comparative information that is available concerning the relative durations of rising and falling tones supports this generalization. Ohala 1978 gives a brief summary of the asymmetries between rising and falling tones, including the experimental observation that speakers can produce a falling pitch interval in less time than the same rising interval, and Gandour 1977 cites Thai and Yuman in addition to Chinese as languages with longer rising tones. The Thai rising tone is about 10 per cent longer than the falling tone; it also does not have as wide a pitch range (Abramson 1962).

[16]This is not always true, at least not in all positions. Lehiste 1970 says that 'it would seem that a fricative might be longer than a sound involving a closure; but this is not always the case.' Two counter-instances that she cites, Breton and Swedish, concern consonants following a stressed vowel. On the other hand, in Carlson and Granstrom's 1988 model of Swedish segment durations, based on a large corpus of connected speech, (voiceless) sibilants have an average inherent duration of 98 msec compared to 54 msec for voiceless stop closures, and 58 msec for voiced closures. Voicing of fricatives may also be a relevant factor. In the connected speech study of Crystal and House 1988a, voiced fricatives were markedly shorter than stops, and unvoiced fricatives were slightly longer than stops (closure + release) overall (97 msec versus 92 msec; but initial **s** was almost twice as long as the closures of initial aspirated stops. The best comparison to the relatively unaspirated **t** in our data would be stressed initial sibilants versus initial **d** closure. Combining Crystal and House's 1988a, 1988c results with those from three other connected speech studies summarized by Carlson and Granstrom 1988 shows that English voiceless sibilants are about 80 per cent longer than **d** closures. O'Shaughnessy 1981 reported that French unvoiced fricatives were 70 per cent longer than stop closures in word-initial position (175 msec versus 103 msec). Initial **s** in Lakhota is substantially longer than **k** (75 per cent longer than the closure, 37 per cent longer including aspiration, according to unpublished data from one speaker collected by Violet Catches and Ruth DeLarios). Japanese **s** is longer than **t** (closure) by 35 per cent (81 msec versus 60 msec) in the intervocalic position of one word pair of the dataset of Port et al 1987. Greek initial **s** is longer than the closures of **p**, **t**, and **k** by 20 per cent (stressed syllable) to 30 per cent (prestressed syllables) in the data of Fourakis 1986.

8

[17]Lehiste 1970 lists seven languages for which this has been verified. Arabic (Mitleb 1984), Japanese (Port et al 1987), Tamil (Balasubramanian 1981), and Thai (Abramson 1962) can be added.

[18]The English diphthongs **ai, au,** and **oi** are about 30 per cent longer than the long low vowels, judging from the measurements of Crystal and House 1988c, Umeda 1975, and Klatt 1976. Abramson's 1962 measurements from one speaker show the Thai inglided diphthongs **ia, ia,** and **ua** about 10 per cent longer than the long low vowels. Lindau 1985 found Hausa **au** to be 45 per cent longer than **aa**, which, however, may have been exaggerated by a difference in the following context (tap versus voiced stop). From the studies on Cairo Arabic by Norlin 1984, 1987, it appears that **ai** is some 10 per cent longer than long vowels, but **iu** and **au** show no difference.

[19]Although O'Shaughnessy 1981 does not provide explicit comparisons of French V and VN durations, his data implies that the shortening of the vowel in VN sequences is much less than the duration of the added nasal, by 100 msec or more.

[20]It is true that larger differences can be found in citation forms. However, our elicitation context in focus position should yield rather larger duration differences than would be found in the great majority of actual utterances. See, for example, the comparisons of Ho 1976 of tone duration differences in various contexts. It is also true that by combining various factors one can arrive at syllables with larger duration differences, e.g. falling tone **tu** versus fall-rise **tian**, which could presumably be perhaps 30 per cent longer. We do not know whether comparing such different kinds of syllables is a fair measure of perceptual invariance or not.

[21]In this Japanese data, the initial consonants whose closure was measured before **a** and **u** were **b** and **k**. Their closures before **u** were longer by only 5 to 7 msec, a little less than the 10 msec or so that we found for **t** before **u** in our data. It is interesting to note that while this initial consonant duration difference in Japanese compensates to some extent for the longer duration of **a**, it is mainly compensation in the duration of the vowel in the following syllable that is responsible for maintaining equal durations of words with the same number of moras.

[22]One additional candidate for onset-rhyme compensation, namely following aspirated stops, deserves consideration. This segment class was not included in our data, but we can deduce roughly what happens from data from Ren 1985 and Svantesson 1987. Both studies are needed, because Ren does not give total syllable or aspiration durations, and Svantesson gives only closure and aspiration durations. The two sets of data are not strictly comparable, since Ren's vocalic durations are averaged over labial, alveolar, and velar onsets, and Svantesson's closure and aspiration durations are for **t** and **th**. Both sets are from high tone syllables with the vowel **a**. The results are nevertheless quite comparable to what we found for other onsets. Svantesson finds closures of 132 msec for **t** and 98 msec for **th**, with aspirations of 11 msec and 102msec, respectively. Ren finds a vocalic duration of 282 msec after unaspirated stops and a duration of 242 msec after aspirated ones. The implied syllable durations are virtually the same: 425 msec versus 442 msec for **ta** and **tha**, respectively. The implied rhyme durations vary rather more: 293 msec versus 344 msecs if aspiration is included, 282 versus 242 if it is not, a difference of 17 per cent in either case. Both shortening of closure and of the voiced vowel duration would be expected in any language; we do not know whether the magnitudes of the Mandarin compensations could be considered large enough to be language specific.

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Colorado Research in Linguistics 11

MORPHOLOGICAL CODING AND SYNTACTIC ROLE IN THE GRAMMAR OF PANJABI COMPLEX SENTENCES

JOSEPH CLIFFORD

Introduction. In South Asian languages, morphology and agreement patterns are characteristically skewed and do not seem to align very clearly with syntactic roles. Such roles, reflected in traditional grammar notions like subject and object, have been routinely identified by reference to the overt 'surface' coding properties word order, case marking and agreement, and an absence of alignment with these properties in a given language may be enough to throw the very existence of such grammatical relations into doubt. In the wake of Keenan's influential cataloging of subject properties (Keenan, 1976) a number of researchers in the area have brought to bear the full battery of covert behavioral properties to argue that a particular argument of the verb may or may not be a 'subject' or 'object', or indeed whether or not these relations were actually viable categories in a particular language (cf. Verma, ed., 1976 inter alia). This paper will attempt to address some of these issues in another South Asian language, Panjabi, an Indo-Iranian language spoken by around 37 million people in northwestern India and Pakistan.[1]

Several English language grammars of Panjabi exist, but they are pedagogically oriented, and limited to main clause syntax (Cummings & Bailey, 1925; Shackle, 1972). The one descriptive grammar (Gill & Gleason, 1963) concentrates almost exclusively on phonology and is somewhat lacking in clarity. Not surprisingly, these traditional grammars have relatively little to offer concerning the questions mentioned above.

My purpose in this paper is thus to try to use certain complex constructions to shed some light on the aforementioned problem of case marking and syntactic relations. In Panjabi and related languages this problem particularly surfaces in attempts to provide a functional description of the so-called 'dative subject construction'. Briefly, since the dative case marker used in this construction also appears with other syntactic roles (primary and secondary objects), and the subject role appears to have other morphological marking, the 'subjecthood' of the dative subject is suspect. I will argue, based on evidence provided in my description of complex constructions, that Panjabi does in fact possess a syntactic role 'subject' revealed in the patterning of some covert behavioral properties, especially the ability to control and undergo deletion in complex clauses, and that the dative-marked 'subject' in general behaves no differently than other subjects with regard to these constructions.

Subject coding in the main clause

Word order. That Panjabi is, like its sister languages, a verb-final language, is both uncontroversial and mundane. To call it an SOV language without further qualification however, is perhaps to beg a nagging theoretical question regarding the status of grammatical relations such as 'subject' in the worlds languages. I shall in this section use the terms 'subject' and 'object' in a pre-theoretical sense to refer to the elements thus identified in the traditional grammars. Subject is the single argument of an intransitive verb, and the agent or (lacking an agent) the experiencer argument of a transitive verb; in general the same as the English translation subject. Objects are any other arguments (besides subject) within