ABSTRACT
This paper examines the structure of /iu/ and /ui/ in Sixian Hakka by means of phonological processes, syllable contraction, co-occurrence restrictions, rhyming patterns, and phonetic measurement. Except co-occurrence restrictions, which fail to reflect the compositional structure of the two diphthongs under investigation, all other linguistic evidence shows that /iu/ is a falling diphthong, and /ui/ is a rising diphthong. The result has two theoretical implications. One indicates that the X-theory (Levin 1985) together with a language-specific sonority hierarchy pinpoints the syllable structure of Sixian Hakka. The other reveals that Selkirk’s (1984) sonority scale of a > e, o > i, u accommodates more languages than the one of a > e > o > i > u proposed by Kiparsky (1979).

This paper discusses the nature of /iu/ and /ui/ in the Sixian Hakka variety spoken in Miaoli, Taiwan from the viewpoints of phonology and phonetics. Evidence from both sides reaches a consensus that /iu/ is a falling diphthong, and /ui/ is a rising diphthong. The so-called phonological evidence, inclusive of phonological processes, syllable contraction, co-occurrence restrictions, and rhyming patterns examines the internal structure of the two diphthongs in question. The result of phonetic measurement reveals that /i/ has higher energy amplitude than /u/ in both cases. In other words, /iu/ presents a falling diphthong, while /ui/ constitutes a rising diphthong.

This paper will proceed as follows. Section 1 presents how phonological processes, syllable contraction, co-occurrence restrictions, and rhyming patterns specify the rimal structure of /iu/ and /ui/. Section 2 shows that phonetic measurement helps identify the two diphthongs. Concluding remarks are given in section 3.

1. PHONOLOGICAL EVIDENCE
This section examines the nature of /iu/ and /ui/ from the perspectives of phonological processes, syllable contraction, co-occurrence restriction, and rhyming patterns.

1.1 Phonological Processes
Chung (1989b:148) argued that the first segments in /iu/ and /ui/ is the nucleus vowel on the premise of phonological processes which operate in the onset. I will contend shortly that
the relevant onset rules may not reflect the syllabicity of their trigger, especially in the cases of /iu/ and /ui/. Instead, it is a glide deletion rule that manifests the nature of the diphthongs with two successive high vowels. Before getting into the details, a digression from [v] is necessary.

It was claimed by Chung (1989b, 1990) that [j] and [v] are not independent phonemes in Liudui Hakka, but are derived from /i/ and /u/ respectively, employing a range of evidence from co-occurrence restrictions and dialectal comparison. For *i* ‘clothing’ in Sixian Hakka, opinions are divided about the phonetic realization of [i]. [yi], or [ji]. By contrast, Sixian Hakka is very much similar to Liudui Hakka with respect to /u/-initial syllables, which are therefore the focus of our discussion.

Hakka dialects have a common denominator that syllables beginning with an /u/, regardless of its syllabicity, are prohibited.


Actually the above ill-formed syllables survive in disguise. According to Chung (1989b, p. 53), a high vowel in the nucleus position spreads to the onset, resulting in a glide, [y] or [w]. Onset Friction (Chung, 1989b:130) follows Onset Spreading, and hence [y] becomes [j] and [w] becomes [v]. Relevant data (Chung, 1989b:130) are given in (2).

(2) a. ji ‘clothing’ * i
    jin ‘seal’ * in
    jim ‘shadow’ * im

    b. vu ‘black’ * u
    vun ‘warm’ * un
    vuŋ ‘to hold’ * uŋ

Chung’s observation holds true to /u/-initial syllables in Sixian Hakka. The forms in (1) surface as follows, respectively.

(3) a. vu, vun, vuŋ, vut, vuk
    b. va, ve, vi, vai, van, vat, ven, vet

Note that two categories are made according to their derivational paths. We follow Chung’s treatment that syllables in (3a) are the outcome of applying Onset Spreading and Onset...
Friction to (1a). Yet unlike Chung (1989b), we hold the position that for cases in (3b), in addition to the two above-mentioned phonological processes, a glide deletion rule motivated by a CG labial constraint, which bans syllables initiated by a string of a labial onset and a prevocalic /u/, comes into play. (An illustration is given in (6).)


Notice that we do not agree at Chung’s stand that the trigger of Onset Spreading must be a [+syllabic] high vowel, which therefore predicts that “the first segment in /ui/ and /iu/ is the nucleus vowel” (Chung 1989b:148). According to Chung (1989b:142-144), the rising diphthong /ua/, for instance, undergoes High Split to ensure that the glide is directly mapped to the onset position, and then Onset Friction changes [w] into [v].

(5) ua □ wa (after High Split) □ va

A question arises as to the necessity of High Split in Liudui Hakka. If Onset Spreading, which amounts to onset insertion, is also triggered by a prevocalic glide, /va/ can be derived from /vua/ by glide deletion.

(6) ua □ wua □ vua □ va

Note that the CG labial constraint also functions in Liudui Hakka. All the ill-formed syllables in (4) do not occur, except pui ‘cup’, p’ui ‘fat’, mui ‘tail’, and fui ‘wrong’. If /ui/ is a rising diphthong like /ua/, the output shall be /vi/. The actual realization of vui ‘stomach’ indicates that /ui/ is a falling diphthong, which meets the environment of Onset Spreading and Onset Friction, but not the CG labial constraint.

(7) ui □ wui □ vui

High Split is superfluous since /ui/ in Liudui Hakka is not an onglided diphthong as it looks like. High Split is also in contradiction with Chung’s (1989b:68) claim that the prevocalic glide is part of the rime and that a rising diphthong occupies an X-slot, which is associated with the nucleus position. This rule can be abandoned without any cost.

Sixian Hakka behaves differently with respect to /ui/ in that no labial onsets can precede it. That [vi] instead of [vui] surfaces reveals its identity as a rising diphthong. One point of
interest is that the high back vowel, be it the nucleus vowel or the postvocalic glide, also affects a vowel-initial suffix in Sixian Hakka. Consider the following data from Luo (1985:100-102), where e is a diminutive suffix.

(8) a. su e  sı su ve ‘tree’  
b. tsu e  sı tsu ve ‘pig’  
c. pu e  sı pu ve ‘cloth’  
d. tiau e  sı tiau ve ‘bird’  
e. keu e  sı keu ve ‘dog’  
f. se meu e  sı se meu ve ‘kitty’  
g. kʱiu e  sı kʱiu ve ‘ball’  
h. se niu e  sı se niu ve ‘calf’

Just like Onset Spreading, Nasal Palatalization (data from Chung (1989b:25)) is also triggered by a high vowel, regardless of syllabicity. Therefore, the onset rules cannot indicate the compositional structure of /iu/ and /ui/. It is the glide deletion rule that identifies the nature of the diphthongs under discussion.7

(9) a. ni  sı nj ‘suspicious’  
b. niam  sı niam ‘weak’  
c. niu  sı niu ‘cow’

Distributional comparison in (10) may also argue for our position about /ui/. Suppose it is a falling diphthong like /oi/, that a labial consonant cannot precede it creates a systematic gap, which calls for an account. If it is a rising diphthong instead, the CG labial constraint explains everything.

(10) a. * pui poi ‘back’  
b. * pʰui pʰoi ‘to toast’  
c. * mui moi ‘sister’  
d. * vui moi ‘to bake in hot ashes’

On the other hand, piu ‘to run fast’, peu ‘watch’, pau ‘to package’ all occur in Sixian Hakka without any violation of labial constraints. Probably /iu/ patterns with the other two rimes as falling diphthongs.
1.2 Syllable Contraction

Syllable contraction furnishes additional evidence for our claim that /iu/ is a falling diphthong, and /ui/ is a rising diphthong in Sixian Hakka. A sonority model proposed by Hsu (1999, 2000b) captures the generalizations of syllable contraction in three Chinese dialects, including Taiwanese, Sixian Hakka, and Mandarin. The gist of this model is given as follows:

(11) Sonority Model

a. Every syllable in Chinese has a three X template, with the nucleus in the middle.
b. Syllable Contraction merges two syllables into one.
c. Edge-in ensures that the association between the melodic tier and the skeleton tier begins with both edges, affecting the onset and the consonantal ending alone.
d. The core sonority scale of a > e > o > i > u, with possible additions in individual languages, determines the nucleus vowel of the contracted output.
e. Syllabification in the nucleus position proceeds in the order of Nucleus Placement, Rising Diphthong Formation, and Falling Diphthong Formation.
f. Maximality demands that the largest possible syllable be constructed as long as the No Crossing Line constraint and language-specific phonotactic constraints are observed.

Below are illustrative examples in Sixian Hakka (Yu 1984) for the sonority model. Though it happens that all the output nucleus vowels in the following cases come from the second source syllable, the sonority model fares better in accommodating more languages.

(12) tûn ‘with’ + ki ‘him’ □ tûi ‘with him’
(13) pun ‘give’ + ki ‘him’ □ pi ‘give him’
(14) tsûo ‘yesterday’ + am ‘night’ □ tsûam ‘last night’
(15) ki ‘how’ + to ‘many’ □ kio ‘how many’

With higher sonority, /i/ shall serve as the nucleus vowel when co-occurring with /u/ as a diphthong. Hence, /iu/ is a falling diphthong, and /ui/ is a rising diphthong.

1.3 Co-occurrence Restrictions

Now let us examine the internal structure of the two diphthongs in question through a co-occurrence restriction. Pursuant to Chung (1989a, 1989b), the ability to precede a consonant distinguishes a rising diphthong from a falling diphthong. On the premise that the former occupies one skeletal slot, while the latter occupies two, no extra X slot is available to
accommodate the consonant, if there is any, after a falling diphthong. Sixian Hakka makes no exception. Consider the following patterns (Yu 1984, Luo 1985).

(16) rising diphthongs               falling diphthongs
    ia – iam, ian, iap, iak          ai -- *ai\(\text{C}\)
    ie – ien, iet                   au -- *au\(\text{C}\)
    io – ion, ioŋ, iok              eu -- *eu\(\text{C}\)
    ua – uan, uat                   oi -- *oi\(\text{C}\)
    ue – uen, uet

A point merits attention concerns /ien/ and /iet/. We agree on Chung’s (1989a, 1989b) position that /ien/ and /iet/ shall be treated as /ian/ and /iat/ respectively. The phonemicization of /ian/ and /iat/ presents pattern congruity. They are phonetically [ien] and [iet] because of co-articulation effect from neighboring segments. Dialectal difference constitutes solid evidence. Hailu Hakka disallows a syllable with zero onset. In Sixian Hakka a syllable-initial prevocalic /i/ surfaces as [\(\text{Z}\)] in the Hailu variety. For instance, ian ‘far’ becomes \(\text{Zan}\) instead of \(\text{Zen}\). Rhyming furnishes further support for the phonemicization of /ian/. In Sixian Hakka /ian/ rhymes with /am/ and /aŋ/\(\text{N}\), which occurs at the phonemic level. Moreover, /ian/ rhymes with /an/ or /en/, lending additional argument for the claim that “members of a rhyming set may not be phonologically identical at any level of phonological representation” (Lin 1989:37). If /ian/ is put as /ien/, an immediate result is: members of a rhyming set, for example /ien/ and /am/, can be phonologically different at any level of phonological representation. One wonders what motivates rhyming then. Suppose the line of thinking is correct, the rising diphthong /ie/ happens to not be followed by any consonant. Accidental gaps occur.\(^{10}\) Based on the patterns in (17), /iu/ is a rising diphthong. Whether /ui/ is falling in nature remains open. The presence of a following consonant is an indicator of a rising diphthong, and yet the absence of a following consonant does not necessarily identify a falling diphthong.

(17) iu – iun, iuŋ, iut, iuk         ui -- *ui\(\text{C}\)

In fact, the phonemicization of /iu\(\text{C}\)/ is misleading. We contend that /iu\(\text{C}\)/ shall be /uu\(\text{C}\)/ instead, where /ü/ is a combination of /i/ and /u/\(\text{.}^{11}\)

Firs of all, /iu/-rimed syllables and /iu\(\text{C}\)/-rimed syllables have different historical origin. The former are derived from Open-mouth Division III rimes, while the latter are derived from Closed-mouth Divisions III or IV rimes. It is generally held by Chinese historical phonologists that Division III rimes and most Division IV rimes show the prevocalic /i/, and Closed-mouth rimes represent the prevocalic /u/. The /iu\(\text{C}\)/-rimed syllables are characterized
by the co-existence of two prevocalic glides, which is attested to by alternative pronunciations of two /iuC/-rimed syllables below.

(18) a. iun, vun ‘to weed’
    b. iun, vun ‘to rely on’

From (18), an immediate question lies in the source of [v]. On the commonly accepted premise that [v] is derived from /u/ (Chung 1989b, 1990), the phonemicization of /iuC/ obviously cannot develop into such an output form. Instead, the more accurate underlying structure shall be /u áuC/, where /u á/ is a combination of /i/ and /u/12. The two prevocalic glides compete, which leads to different surface representations.

Distributional patterns seem to also argue for the phonemicization of /u áuC/. If the /iuC/ rimes really occur as /iu/ plus a consonant, /iu/ distinguishes from other rising diphthongs in its inability to follow a labial consonant. The systematic gap of a sequence of a labial consonant plus an /iuC/ rime can result from the CG labial constraint.

(19) a. ia pian, pian, piat, piak
    b. io pio, *pio, *piok
    c. iu *piun, *piu, *piut, *piuk

Rhyming patterns lend further support for our position that /iuC/ is not developed from /iu/. An observation by the present author reveals that /iu/ rhymes far more often with itself than with /u/, while an opposite picture is seen in the case of /iuC/. Word frequency cannot make an escape. The occurrence ratio between /iu/ and /u/ is similar to that between /iuC/ and /uC/. Details concerning rhyming patterns will be given in section 1.4.

In Hakka, /á/ does not occur in isolation, and hence phonologists never treat it as an independent phoneme. The former phonemicization of /iuC/ is based on pattern congruity though its phonetic status has been claimed to be very much like [üC] in the literature (Yang 1971, Hashimoto 1973, Chung 1989b).13 We have argued that /iuC/ does not grow out of /iu/ followed by a consonant, but shall be /üuC/ instead. In lieu of this, /iu/, same as /ui/, happens to not precede any consonant, which does not help to identify the compositional structure of the two diphthongs.

1.4 Rhyming Patterns

In addition to syllable contraction, rhyming patterns present one more solid argument for /iu/ to be a falling diphthong. As mentioned in the previous subsection, /iu/ rhymes much more frequently with itself than with /u/ even though /u/-rimed syllables are about three times
the number of /iu/-rimed syllables according to a dictionary by Hsu et al (1992). A plausible interpretation based on occurrence frequency is: strict rhyming is preferred in Sixian Hakka, and /iu/ is a rising diphthong. Yet a sharp contrast from /ui/ rules out this possibility. Cases of ui/i rhyming exceedingly outnumber those of ui/ui rhyming. If /iu/ is a falling diphthong instead, a question arises concerning why /iu/ rhymes with /u/ on the premise that rhyming requires the identity of the nucleus plus the coda. Consider the following folk songs ((20-22), see Lai, 1993; (23-26), see Liu, 1994.)

(20) 靜靜種竹葉轉烏，莫來想爭人丈夫；
     vu               fu
     一夫一妻天註定，榮華富貴一生有。

(21) 哪有好賭介朋友，聽我勸解早日收；
     iu               su
     事業頭路認真做，打拼顧家不用憂。

(22) 無人像我按無修，愁急兩字日日有；
     c                 iu
     可比竹竿曬爛衫，曬日曬夜無人收。

(23) 小溪出谷望長流，種地耕田望豐收；
     iu                 iu
     阿哥貧窮妹唔怕，做來做去總會有。

(24) 阿哥愛轉妹愛留，流轉阿哥妹較輸；
     iu             iu
     三餐煮飯放加米，煮菜也愛放加油。

(25) 川字三點嘉應州，天字出頭妹麼夫；
     iu             iu
     右字肚裡加兩點，看妹容顏難得有。
According to Hsu (2000), Sixian Hakka allows peculiar rhyming sets in which the partners share identical final vocalic segment regardless of syllability, as exemplified by the following puzzles ((27-28) from Liu 1992), folk songs ((29-37) from Liu 1994, (38-42) from Lai 1993), and nursery rimes ((43-44) from Hsieh 1995).
人生似鳥同林宿，大限來時各自飛。

火焰山南道作堤，狂濤過退大安溪；
從今風雨侵沙岸，石不崩移路不迷。

大路行來細路歸，不驚旁人多是非；
爛盤石上曬燈草，有心不驚大風吹。

山歌本係三妹留，留給世間被你丟；
三餐就愛妹送飯，睡目就愛哥貼頭。

耕田愛耕上下坵，上邊有水下邊有；
兩邊有水來相濟，就係天旱唔使愁。

哥哥送我到牆頭，牆頭有棵好石榴；
一心想摘哥哥食，恐驚知味又來偷。

一盞孤燈照夜台，上床脫袴又脱鞋；
三魂七魄隨夢去，誰知明朝來不來？

只有溫柔正自在，強暴烈性必生災；
行善自有天保佑，刁唆橫詐係禍胎。
隔河看條大水牛，口含青草目汁流；
牛哥牛哥叫什麼？我叫一年苦到頭。

食口泉水涼心頭，唱條山歌解心憂；
清泉解得心頭火，山歌能解萬年愁。

阿哥走裡妹就愁，三朝七日唔出頭；
三朝七日唔洗面，每日目汁都雙流。

田唇草，開紅花，阿二嫂，轉妹家，初一去，初二轉，
轉來雞嬤無生卵，雞公哇哇啼，牛嬤無有胎，牛仔學拖犁。

月光光，樹頂背，鵝嘻水，鴨洗菜，雞公碪穀狗踏堆，
狐狸燒火羊炒菜，貓公走去拈魯箕，老鼠偷吃烙疤嘴。

As for /ui/, below are some examples from folk songs ((45-49) from Lai 1993, (50-52) from Liu 1994). Given the unusual rhyming practice, we cannot exclude the possibility that /ui/ is a falling diphthong. Yet the chance is slim for two reasons. As mentioned before, /ui/ rhymes far more often with /i/ than with itself. In addition, the peculiar rhyming patterns never stand for the norm. /ui/ is better treated as a rising diphthong.
揚搖仔，搖搖飛，大姑踏板細姑篤，
千年姊妹料毋飽，捏忒肚腸來去歸。

飲酒人人都望醉，讀書人人都望貴；
戀哥都是望長久，希望雙竹會透尾。

眼箭棲來眼箭飛，梳草阿哥像烏龜；
用手爬來腳又彎，屁吻孔孔少條尾。

天上燕子走飛飛，月頭看哥到月尾；
一月看哥兩三擺，分妹擔名真缺虧。

上樹採花花落水，下水撈花花又推；
命中無帶桃花命，走入花園空一回。

上樑燕子下樑飛，同陣出門獨自歸；
阿哥走裡麼信轉，目汁流來好洗衣。

翅仔初長學交飛，二人見面係出回；
新鳥出門心膽細，請哥不要急來追。

In addition, nothing of particular interest concerns the rhyming of /iuC/. That it generally pairs off with /uC/ abides by the requirement of the identity of the nucleus vowel plus the coda. Illustrative data are adopted from Liu (1994). Note that different rhyming
patterns between /iu/ and /ũuC/ also sheds light on the argument that the phonemicization of /ũuC/ is misleading. The alleged rime does not develop from /iu/.

A summary of this section is: except the co-occurrence test of whether to precede a consonant or not, phonological processes, syllable contraction, and rhyming schemes all suggest that /iu/ is a falling diphthong, while /ui/ is a rising diphthong in Sixian Hakka. The next section will present that the same conclusion is corroborated by a pilot production experiment.
2. PRODUCTION EXPERIMENT

2.1 Methods

The data set of this experiment is bipartite. One presents isolated syllables, including ten /iu/, nine /ui/, seven /i/, and six /u/-rimed syllables. The other are disyllabic phrases initiated by some of the above-mentioned isolated syllables which are composed of five /iu/, four /ui/, seven /i/, and six /u/-rimed cases. The reader is referred to the Appendix for more details.

Tone was controlled in the experiment. All the target syllables carry a high level tone. When occurring in a disyllabic phrase, they are all followed by a syllable with the same pitch, and in addition, with a voiceless onset.

Two native Sixian Hakka speakers, both male, served as subjects. They were both born and grew up in Miaoli. One acquired Sixian Hakka from his mother, and had some exposure to Taiwanese after senior high school. The other had Sixian Hakka-speaking parents, and learned Taiwanese from TV. In addition, both subjects spoke Mandarin. Neither of them had speech or hearing problems by self-report.

The recordings were made in the sound booth at the Foreign Languages and Literatures Department of the National Chiao-Tung University. The thirty-two isolated syllables and twenty-two disyllabic phrases were read three times in random order. The recording is done using a SONY MZS-R4ST MD. The recorded data was saved into computer through Sound Blaster Pentium Live, and then measured and analyzed by Cspeech ver 4.0-Lab Automation.

The recordings were digitized (10 kHz sampling). Energy amplitude of $F_2$ was measured for the speakers’ repetitions of each of the tokens. Mean energy amplitude of /i/ was calculated for all tokens with the same rhyme, separating target syllables in isolation and those in the phrasal context. The same analysis was done for /u/. The difference of mean energy amplitude between /i/ and /u/ was examined by t-tests in individual diphthong-rimed syllables within the same environment. As for the monophthongs, the difference of mean energy amplitude between /i/ and /u/ in isolated syllables was inspected by a t-test, so was the case of /i/ and /u/ in the phrasal position.

2.2 Results

The results of t-tests showed that the difference of mean energy amplitude between /i/ and /u/ in individual diphthong-rimed syllables was statistically significant at $\alpha$ level = 0.01, both in isolation and in the phrasal position. Consider the following tables.
Table 1. T-test Result of /iu/ in Isolated Syllables

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>57</td>
<td>57</td>
</tr>
<tr>
<td>Mean</td>
<td>-41.0509</td>
<td>-48.7571</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>5.8364</td>
<td>4.5462</td>
</tr>
</tbody>
</table>

T = 7.838    P = 0    df = 105.042

Table 2. T-test Result of /ui/ in Isolated Syllables

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>Mean</td>
<td>-37.2426</td>
<td>-47.156</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>10.9016</td>
<td>6.8101</td>
</tr>
</tbody>
</table>

T = 5.667    P = 0    df = 88.898

Table 3. T-test Result of /iu/ in the Phrasal Position

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Mean</td>
<td>-38.1133</td>
<td>-45.5633</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>6.8349</td>
<td>5.6214</td>
</tr>
</tbody>
</table>

T = 4.611    P = 0    df = 55.917

Table 4. T-test Result of /ui/ in the Phrasal Position

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Mean</td>
<td>-38.3208</td>
<td>-47.554</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>5.2139</td>
<td>5.3348</td>
</tr>
</tbody>
</table>

T = 6.064    P = 0    df = 45.976

The doubt that /i/ may intrinsically have higher energy amplitude than /u/ is cleared. According to the tables below, the difference of mean energy amplitude between /i/ and /u/ in monophthongal structures is not statistically significant at $\alpha$ level = 0.01, either in isolation or in the phrasal position.
Table 5.  T-test Result of /i/ and /u/ in Isolated Syllables

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>42</td>
<td>36</td>
</tr>
<tr>
<td>Mean</td>
<td>-35.8952</td>
<td>-34.7306</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>5.1942</td>
<td>3.8815</td>
</tr>
</tbody>
</table>

T = -1.131  P = 0.262  df = 74.689

Table 6.  T-test Result of /i/ and /u/ in the Phrasal Position

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>42</td>
<td>36</td>
</tr>
<tr>
<td>Mean</td>
<td>-36.5214</td>
<td>-33.325</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>6.4033</td>
<td>4.9538</td>
</tr>
</tbody>
</table>

T = - 2.482  P = 0.015  df = 75.262

On the premise that energy amplitude is in direct proportion to sonority, a conclusion drawn from the experiment is: when /i/ meets /u/, the former is more sonorous than the latter. Given that there is only one sonority peak per syllable, between the two high vocoids, the one with higher energy amplitude is regarded as the nucleus. Therefore, /iu/ is a falling diphthong, and /ui/ is a rising diphthong.

A question ensues at this point concerning if energy amplitude constitutes reliable additional evidence for our phonological arguments. According to Ladefoged (1993:188), “in any utterance, the actual intensity of a segment will depend on many factors, such as its position in the sentence, the degree of stress on each word, and the personal characteristics of the speaker.” In other words, intensity of a segment varies from context to context and from speaker to speaker, and hence our attempt to employ acoustic display as a reflection of the segmental status of /iu/ and /ui/ might fail.

As a matter of fact, our findings from Sixian Hakka are not language-specific. Similar outcome is obtained in another study on Taiwanese (Hsu 2001). Furthermore, previous studies on /i/ and /u/ in American English also manifest the correlation of intensity and relevant phonological traits. Edwards (1997:378) summarized the results of acoustic measurements in Fry (1979) and Levitt (1978) who conducted very similar studies of the relative acoustic powers of the English speech sounds, and stated

“average power is expressed in reference to /θ/ which is the English sound with the lowest intensity and hence a value of “1.0” is arbitrarily assigned to it. The average differences in intensity between all other sounds and this
reference sound are given in the table in decibels, with the sounds arranged in descending order of intensity.”

In addition to the reference sound, Table 7 below only gives the values of /i/ and /u/ which interests us here. The only conclusion we can draw from this table is: /u/ has higher intensity than /i/. When they co-occur as a diphthong, /u/ is the nucleus and /i/ is the glide. In case /i/ occurs before /u/, the combination will be /ju/. The reversed situation yields /uy/.

Table 7. Relative Acoustic Power for the English Phonemes /i/ and /u/

<table>
<thead>
<tr>
<th>Sound</th>
<th>Average Power [in dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>u</td>
<td>21.5</td>
</tr>
<tr>
<td>i</td>
<td>20.5</td>
</tr>
<tr>
<td>θ</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Our prediction holds true. Though opinions are divided as to the belonging of /j/ (Barlow 2001, Davis and Hammond 1995, Yip 2001), we believe /ju/ ‘the only rising diphthong in American English’ (Edwards 1997: 331). Reasons ever pointed out in the literature that may argue for /ju/ as a diphthong are summarized as follows. First of all, /j/ only occurs before the vowel /u/, as in pure and cute, suggesting that it forms part of the rime. Second, voiced fricative + sonorant sequences are prohibited in American English, yet /vj-/ sequences occur. Third, initial NC clusters are generally banned, yet /mj-/- and /nj-/ occur. Fourth, variation between /ju/ and /u/ after coronals in dialects of American English lends evidence for /ju/ as a rising diphthong in that the nucleus remains intact while the onglide may disappear. Fifth, the antepenultimate stress in mérécury reveals /ju/ being treated as light in stress assignment. That a rising diphthong, as opposed to a falling diphthong, occupies an X-slot explains why –cu does not receive stress. Sixth, data from ‘Name Game’ also indicate that the prevocalic glide in a CjV sequence is associated with the following vowel. In addition, historical development indicates the derivation of /ju/ from borrowing of French /ü/ at the stage of Middle English. “The complex particle configuration of a monophthong is split up to become a sequence of particles for the diphthong.” (Schane 1984:135) On the other hand, the only plausible argument, I think, against /ju/ as a diphthong is that it does not occur after clusters, for instance *[plj]. Finally, of much interest is a dual picture presented by /j/ in Pig Latin (Barlow 2001). C/ju/ sequences are represented differently within and across adult speakers. /j/ forms either part of a complex onset or part of a diphthong. That the inconsistent results from Pig Latin does not change our position that /ju/ is a rising diphthong finds an account from Bao (2000:307),
“the phonology of a language game need not be identical with the phonology of the language on which the game is based. This is not only true of La-mi in Fuzhou, but also of the Chinese-based language games… This phenomenon is common in language games cross-linguistically. (Cf. Bagemihl, 1989; Ito et al., 1996).”

By contrast, /uy/ never occurs as a falling diphthong in American English. Instead, its fraternal twin /wi/ survives, not in the form of a diphthong, but a sequence of the onset plus the nucleus. Pursuant to Jensen (1993:66), possible occurrence of two-consonant\(^2\) onsets in English indicates that 14 consonants can precede /ju/, with the exception of /fl/. This contrasts sharply with /wi/. Only /tl/, /kl/, and /ls/ can be prior to it. In fact, the cluster /Cw/ is foreign in origin or unusual. This asymmetrical occurrence frequency may well explain why /wi/ is not a diphthong. Davis and Hammond (1995) further corroborate that the prenuclear glide in a CwV sequence is treated as part of the onset, on the basis of phonotactic evidence and data from Pig Latin and ‘Name Game’.

3. CONCLUDING REMARKS

This paper have argued that in addition to the co-occurrence restriction which fails to identify the rimal structures of /iu/ and /ui/, phonological processes, syllable contraction, rhyming patterns and acoustic measurement all indicate that /iu/ is a falling diphthong, and /ui/ is a rising diphthong in Sixian Hakka. An ensuing implication concerns syllable theories. Chung (1989b:62) rejected the traditional syllable structure for Chinese languages, namely CGVX, for “in a syllable with two high vowels, [it] makes no predictions as to which segment is the nucleus vowel, which is the medial, and which is the vocalic ending, because either i or u can be a medial glide, a nucleus vowel, or a vocalic ending”. Likewise, the XXX syllable template (with the nucleus in the middle) proposed by Chung is unable to predict the nature of the diphthongs under investigation either. Both rising diphthongs and falling diphthongs are projected into the nucleus position. The only difference in between is: the former occupies one X slot, while the latter occupies two. At first glance, the CV-theory (Clements and Keyser 1983), which specifies vowels and consonants in the skeletal tier, fares better. Yet the problem of how to predict the syllabicety of a high vowel remains unsolved, not to mention the awkwardness due to underlying specifications. As a matter of fact, the X-theory (Levin 1985) together with a language-specific sonority scale manages to point out the compositional structures of /iu/ and /ui/. In Sixian Hakka, the more sonorous /i/ surfaces as the nucleus vowel. Another theoretical implication of this paper concerns sonority hierarchy. Kiparsky (1979) proposed a sonority scale of a > e > o > i > u, which holds true in Sixian
Hakka, but not in American English. Instead, the one claimed by Selkirk (1984), namely a > e, o > i, u, accommodates more languages.

NOTES

* I would like to thank Professor Ho-Hsien Pan for valuable suggestions and comments on the phonetic part of this study. Without her, the interdisciplinary research will not be possible. Thanks also to Professor Kuang-yu Chang for enlightening guidance on historical development of the Chinese phonology. Of course, I myself shall assume full responsibility for remaining errors.

1 In this paper, rhyme means sameness of sounds in verse, and rime indicates the subsyllabic constituent composed of an obligatory nucleus and optional prevocalic glide and coda.

2 Hashimoto (1973) used the symbol j to indicate the palatal fricative [ʒ].

3 Though the reader may wonder if the application of Onset Spreading before Onset Friction is necessary, Chung made such an analysis to take care of dialectal variation.

4 This rule is renamed as High Spreading in Chung (1990).

5 Mandarin (Pulleyblank 1989) and English undergo a similar constraint. Sixian Hakka differs from the two languages in that no specific subsyllabic domain in which the constraint applies can be delimited since the prevocalic glide in Sixian Hakka is part of the rime (Chung 1989b:68-80).

6 Dialectal difference between Liudui Hakka and Sixian Hakka concerning the compositional structure of /ui/ awaits further phonetic investigation.

7 That /iu/ ‘oil’ is realized as [zu] in Liudui Hakka and Hailu Hakka may attest to the ongiled nature of /i/. Yet dialects can differ as to which segment of /iu/ is the nucleus vowel.

8 Maximality predicts that \( ^{\text{t}}\text{ui} \) shall surface as the contracted form. For this exception, we have no account at this moment. Yet, the output does reflect the higher sonority of /i/ than /u/.

9 Prevocalic glides may not take part in rhyming.

10 According to Hsu (1999), Taiwanese exhibits the same picture. That /ue/ precedes no consonant does not undermine its nature as a rising diphthong.

11 In fact, many historical phonologists (Tung 1985, Li 1984, among others) assume the existence of a compound medial –iu- in Middle Chinese. This paper posits \( ^{\text{u}}\text{iu} \) merely to fit into the syllable structure of Hakka.

12 The phonemicization of /ũuC/ finds further support from the surface representations of vian and viaq ‘far, courtyard’ in Yungding Hakka and Changting Hakka respectively, as opposed to ian in Sixian Hakka (Chang personal communication). Note that the syllables in question are pronounced as ian in Mandarin.

13 The same finding is obtained in a production experiment conducted by myself.

14 One of the distinctions between strict rhyming and loose rhyming lies in the involvement of prevocalic glide or not.

15 If the folk songs were sung in Hailu Hakka, the rhyming pattern would differ. Yet, according to Lai (1993:7), Sixian Hakka is the so-called official language, which is used for the recital of poetry to best present the beauty of rhyming. Hakka folk songs are generally characterized by the style of heptastich, and people are used to singing them in Sixian Hakka.

16 Orthography rather than transliteration of examples in this subsection is given for the
focus of discussion is the final syllables of the rhymed lines.

17 To my knowledge, this peculiar rhyming property is not seen in Mandarin Chinese and Taiwanese Min.

18 Duration and formant distribution are to be measured. This paper only presents the outcome about energy amplitude.

19 In the case of Taiwanese, /i/ has higher energy amplitude than /u/ either when it forms part of a diphthong or when it occurs as a monophthong. The difference between Sixian Hakka and Taiwanese may result from design of data set with respect to isolated monophthongal syllables. CV syllables are used for Sixian Hakka (since /u/ never surfaces), and V syllables for Taiwanese. The place of articulation of the onset may affect the energy amplitude of the nucleus.

20 Likewise, Ladefoged (1993:246) claimed that /u/ has higher sonority than /i/. Sonority has correlation with jaw movement. The lower a vowel is, the more sonorous it is. In English /u/ is lower than /i/ in terms of tongue height (Ladefoged 1993:197).

21 Jensen regards /j/ as part of the onset.

APPENDIX

1. /ui/ in Isolated Syllables
   tui ‘pair’       sui ‘fragments’       kʰui ‘cupboard’
   lui ‘tears’      tʰui ‘to retire’      kui ‘expensive’
   ŋui ‘Lastname’   tsui ‘drunk’        tsʰui ‘to fall’

2. /iu/ in Isolated Syllables
   ŋiu ‘small’      kiu ‘to save’        siu ‘to embroider’
   tʰiu ‘to slide’  liu ‘to steam’       kʰiu ‘old’
   hiu ‘yell’       tsiu ‘wrinkle’       tsʰiu ‘sleeve’
   iu ‘young’

3. /ui/ in Disyllabic Phrases
   tui tiau ‘to exchange’    tsʰui fam ‘criminal’
   tʰui fo ‘to return goods already purchased’  sui hi ‘auspicious air’

4. /iu/ in Disyllabic Phrases
   kiu fu ‘to relieve and nurse’  siu si ‘to embroider words’
   kʰiu fo ‘old goods’    tsiu tsiu ‘wrinkled’    iu hi ‘to go again’

5. /i/ in Isolated Syllables
   pʰi ‘nose’      tʰi ‘earth’        li ‘severe’      ki ‘to send’
   hi ‘to go’      tsi ‘to worship’    si ‘four’
6. /u/ in Isolated Syllables
pu ‘cloth’  pʰu ‘section’  tʰu ‘to take care’
lu ‘road’  fu ‘to nurse’  tsu ‘to pour’

7. /i/ in Disyllabic Phrases
pʰi kian ‘nose’  tʰi pʰu ‘condition’  li hoi ‘fierce’
ki sin ‘to send a letter’  hi kʰon ‘go to see’
ysi si ‘to worship’  si pʰi ‘four times’

8. /u/ in Disyllabic Phrases
pu sui ‘cloth shreds’  pʰu fun ‘part’  tʰu hi ‘to take’
lu hoŋ ‘on land’  fu si ‘nurse’  tsu sa ‘to inject’

REFERENCES


Singular Publishing Group, Inc.


University of British Columbia.