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The Phonetics of Paiwan Word-Level Prosody*

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In this paper the phonetic correlates of word-level prosody of an indigenous language were examined as a case of supporting the argument that phonetic representation plays a role in the documentation of phonology. Piuma Paiwan has a quality-sensitive stress in which peripheral vowels such as /i/, /u/, and /a/ are more optimal than the central schwa, and the primary stress falls on the most sonorant or the most optimal vowel. However, a schwa nucleus can bear stress in the other Paiwan dialects. On the other hand, imperative accent may result in the pitch peak aligned with the final syllable. Stressed syllables always have higher pitch than unstressed syllables, and pitch tends to be a robust cue to word-level stress and accent in Paiwan. The results suggest that word-level prosody in Paiwan is best modeled in terms of f0 realization.

Key words: phonetics, Paiwan, word-level prosody

1. Introduction

This paper investigates the phonetic correlates of stress and word-level prosodic features in Paiwan. Paiwan is an Austronesian language spoken in Taiwan, with around 66,000 speakers. Paiwan is notable for its large number of consonantal phonemes, compared with the other Formosan languages. The importance of Paiwan has been mentioned in Ferrell's (1982) dictionary. Paiwan does not show extensive mergers and splits among Proto-Austronesian (PAN) stops. The significance of Paiwan lies in its phoneme inventory directly comparable to the PAN inventory proposed in Dempwolff's (1934-38) and Dahl's (1973) reconstruction studies. The Paiwan language has parallel

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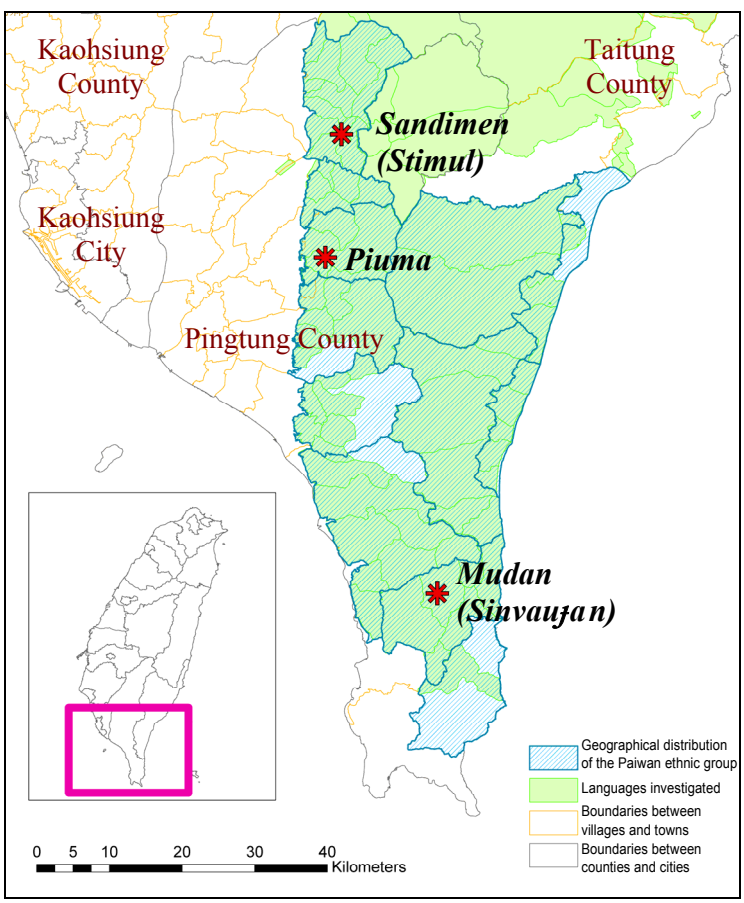
palatal stops which are rarely attested in other Formosan languages, and the merger of palatal stops also occurs in some varieties of Paiwan. An attempt has been made in Ho's (1978) comparative study to reconstruct Proto-Paiwan. Yet, a comprehensive description on Paiwan phonology, drawn from fieldwork data and empirical evidence, is still needed. Maddieson (2001) has pointed out that the majority of field reports on languages give rather minimal details on their phonetic properties, sometimes nothing more than a list of symbols. Though the phonological inventories of Paiwan have been constructed (Ho 1977, 1978, Chang 2000, 2006, Pulaluyan 2002), it varies from one fieldwork documentation to another. Furthermore, most of the existing documentation provides little empirical phonetic evidence for the phonological patterns, not to mention stress and word-level prosody.



Map 1:[1] The distribution of the Paiwan villages

[1] This map is based on those prepared by the GIS Team of the Computing Center, Academia

The investigation of the Paiwan language includes the following villages: Sandimen (Stimul, 三地門), Piuma (平和), and Mudan (Sinvauɟan, 牡丹). The distribution of the Paiwan villages is illustrated in Map 1.

Ten informants aged 48-70 participated in the study. All of them speak Paiwan very fluently. The study assesses phonological varieties among the Paiwan village dialects. Other members of the villages might not share some of the phonological and phonetic features reported here, as some variation was attested among and within the villages. More than half of the sound files were collected in the Piuma Paiwan village, one of the oldest villages in Pingtung County. Sounds files recorded in the other villages were compiled for the investigation of phonological variation. Piuma Paiwan village is presently located in the mid-eastern part of Pingtung County.[2] The village is surrounded by mountains. More than 95% of the residents in the community are Paiwan aborigines. Non-Paiwan residents in the community are mainly spouses of the Paiwan people. Paiwan is the primary communication language in the village. The younger Paiwan generation there has relatively little opportunity to speak their mother tongue. The factor of language contact will probably more greatly influence the prosodic patterns of the Paiwan language.

Table 1: Piuma Paiwan consonants

	Labial[3]	Alveolar	Retroflex	Palatal[4]	Velar	Uvular	Glottal
Plosive	p b	t d	ɖ	c ɟ	k g	q	ʔ
Fricative	v	s z					(h)
Affricate		ts					
Trill		r[5]					
Nasal	m	n			ŋ		
Lateral			ɭ	ʎ			
Approximant	w			j[6]			

Sinica (http://webgis.sinica.edu.tw/twnlanguage/viewer.htm). Names of the Paiwan villages investigated in the present study are italicized. The author wishes to thank Lin Chih-hsien for his assistance in the re-drawing of the map.

[2] According to an anonymous reviewer of *Language and Linguistics*, the Piuma village was relocated to its modern location in the 1960s. The reviewer also mentioned that earlier Japanese scholars (e.g., Utsurikawa et al. 1935) show both Piuma and Makazayazaya as members of the so-called "Butsul" group of villages. A recent ethnological study (Yang 2005) confirms that the Piuma village belongs to the "Butsul" group, and the villagers of Piuma moved to the present location from the old village in 1968.

[3] The labial category here includes two places of articulation: bilabial and labiodental. Phonemes /p/, /b/, and /m/ are bilabial consonants, whereas /v/ and /w/ are labiodental phonemes.

[4] Following Ferrell (1982), palatal [c], [ɟ] and [ʎ] are transcribed as [tj], [dj] and [lj] respectively in earlier literature of Paiwan and the majority of the language teaching materials.

[5] Piuma Paiwan /r/ has the allophonic alternation of voiced velar fricative [ɣ].

[6] The phoneme /j/ is often conventionally transcribed as /y/.

The consonant inventory of the Piuma Paiwan village dialect is shown in Table 1. A loan phoneme is shown in parentheses. Piuma Paiwan has twenty-three consonant phonemes and one loan consonant phoneme /h/. The glottal stop is somewhat marginal.

Due to frequent immigration, intermarriage, and communication with outsiders, it is rather difficult to mark the boundary between regional dialect groups. Within each Paiwan dialect, some variation was found between village communalects.[7] Ferrell (1982: 4-5) has reported that phonologically "central and southern Paiwan villages tend to form a loose grouping, opposed to an even more heterogeneous grouping of northern and eastern villages." This indicates that the phonological distinction among the Paiwan aborigines does exist. Membership in each dialect group is determined phonologically.

The study focuses on the fundamental frequency correlates of stress and accent in the speech of Paiwan speakers. The interaction between stress and vowel length in Austronesian languages has been discussed in Wolff's (1993) comparative study. Yet, whether vowel length is a phonetic realization of stress in Paiwan is unknown, and phonetic cues to Paiwan stress are never examined in earlier study. The study of prosody in Austronesian languages is rather scanty. Moreover, the term 'accent' has been used to describe various aspects of prosody. Zorc (1993), for instance, classifies Paiwan as an Austronesian language with accent falling regularly on the penult. Wolff's (1993) work on PAN accent patterns does not distinguish accent from stress, as he argues that in Proto-Austronesian (PAN) the stress patterns fell on the penult of the root if it was long (or accented) and on the final syllable of the root if the penult was short (or unaccented). It is rather vague, under Wolff's (1993) reconstruction, whether stressed or accented syllables are always long in PAN. The work on accentual contrasts and the feature of PAN stress is still in its infancy (cf. Wolff 1993). On the other hand, variation of the accent patterns of Paiwan has been attested in recent empirical work (Chen 2004). Informants under the age of fifty tend to over-generalize specific prosodic pattern in their speech. Gussenhoven (2004) points out that the notions 'stress', 'tone' and 'accent' all refer to suprasegmental aspects of the phonological structure, but they are in fact rather different. Generally speaking, stress can be predicted on grammatical grounds. In a stress language, every utterance has a rhythmic structure, and the rhythmic structure serves as an organizing framework for the utterance's phonological and phonetic realization (Hayes 1995). A stressed syllable is frequently characterized by a pitch change, by greater duration and by greater intensity (Bolinger 1958, Fry 1955, 1958). On the other hand, it has been disclosed that pitch accent languages such as Japanese use pitch as a correlate of stress to a greater extent than English (Beckman 1986). Chiang & Chiang (2005) claim that Saisiyat, another Austronesian language spoken in Taiwan, is a pitch

[7] The term "communalect" was pointed out by one anonymous reviewer of *Language and Linguistics*. It refers to "village-specific sub-dialects in contrast to regional dialect groups".

accent language. They measure various prosodic parameters of syllable rhymes, such as f0 height at onset, offset, peak and trough, pitch range, duration, and slope of content words in Saisiyat, and they suggest that accent in Saisiyat should be classified as pitch accent. Though they do not distinguish phonological accent from phonetic accent, and no minimal pairs with distinctive features are found in their lexical accent patterns, their account has been an innovative view for the empirical analysis of prosody in Austronesian languages.

Paiwan has a quantity-insensitive stress. Li (1977) has pointed out that stress plays a part in the morphophonemic changes undergone by some Formosan languages. Wolff (1993) argues that in the Philippines, which is the only area in which PAN root stress or length is currently still retained in attested languages, the contrast consists of vowel length in most cases, and stress is predictable in terms of length. The current study describes phonological stress and investigates word-level prosodic effects, two phenomena which have never been published in any earlier theoretical study or field report. Empirical studies have been conducted to verify the phonological variation and prosodic features in the speech communities of Paiwan.

2. Stress

2.1 Distribution of Piuma Paiwan stress

Paiwan stress falls on penultimate syllables in general. However, there are a few exceptions. The description of stress in Piuma Paiwan is given in (1).

(1) a. In disyllabic and longer words, stress falls on the penultimate syllable.

Paiwan	Stress	Gloss
gadu	gádu	‘mountain’
tsaviʌ	tsáviʌ	‘year’
ŋuɟus	ŋúɟus	‘nose’
ɭigim	ɭígim	‘needle’
tutaŋ	tútaŋ	‘aluminum’
vavajan	vavájan	‘woman’
vitsuka	vitsúka	‘stomach’
tsaʌiŋa	tsaʌíŋa	‘ear’
kaɟunaŋan	kaɟunáŋan	‘earth’
kavaʌiŋa	kavaʌíŋa	‘thenar’
kaʌaʌuŋan	kaʌaʌúŋan	‘middle finger’

b. When the nucleus of the penultimate syllable in a word is a weak schwa [ə], stress shifts to the last syllable of the word; when both penultimate and last nuclei are schwa [ə], stress falls on the last [ə].

Paiwan	Stress	Gloss
vəcək	vəcə́k	'elder sibling'
kəməlaŋ	kəmələ́ŋ	'to know'
masəŋsəŋ	masəŋsə́ŋ	'to make something'
mipərəpərər	mipərəpərə́r	'to fly'
cəvus	cəvús	'sugarcane'
kəman	kəmán	'to eat'
səmənav	səmənáv	'to wash (dishes)'
zaɭaŋəzaŋ	zaɭaŋəzáŋ	'hot weather'

Stress patterns in Paiwan can be divided into two types: quality-sensitive and quality-insensitive. Kenstowicz (1996) has documented several diverse languages in which vowel quality plays a comparable role in determining the location of stress. He has proposed a vowel sonority hierarchy and showed that peripheral vowels such as /i/, /u/, and /a/ are more optimal than central vowels such as schwa. In a quality-sensitive stress system, stress seeks out the most optimal vowel. On the other hand, Crowhurst & Michael (2005) have shown an interaction between quantity and quality of stress. They have proposed universal scales of Quantity, Coda, Height, and Diphthong, which are expected to be invariant across languages.

Piuma Paiwan has a quality-sensitive stress system. In a quality-sensitive stress system, the primary stress falls on the most sonorant or the most optimal vowel. Vowel-sonority hierarchy interacts with the assignment of stress. On the contrary, when vowel-sonority hierarchy does not play a role in the assignment of stress, the system is quality-insensitive in terms of the parameter in the typology of stress.

In Piuma Paiwan, the primary stress falls on either the penultimate (second-right) or the final (rightmost) syllable, depending on whether the penult has a schwa nucleus and the syllable number of the roots. Schwa affects the stress system in Piuma Paiwan, but not that in Sandimen and Mudan Paiwan village dialects. The stress patterns in Piuma Paiwan are subject to the quality of vowels, i.e. quality-sensitive. Roots, stems, and derivation forms in Paiwan can form a prosodic word to which stress can apply. The distribution of Piuma Paiwan stress is given in (2).

(2) a. Stress goes on the final syllable (i) if the prosodic word is monosyllabic, or (ii) if the penultimate syllable of the prosodic word has a schwa. Otherwise, stress falls to the penult.

Piuma Paiwan	Stress	Gloss
ɟiʎ	ɟíʎ	'hip'
vat	vát	'husked rice'
pu-pan	pupán	'to bait'
ma-pə-tad	mapətád	'to dry (something)'
pa-ki-kan	pakikán	'to feed (animals)'
k-əm-ats	kəmáts	'to bite'
cəvus	cəvús	'sugarcane'
tsəməl̩	tsəmól̩	'foliage'
qurəpus	qurəpús	'cloud'
qapədu	qapədú	'gall'
ʎisəqəs	ʎisəqə́s	'nit'
quʎivaŋəraw	quʎivaŋəráw	'rainbow'

b. In a disyllabic or longer prosodic word, stress falls on the penult of the word, regardless of the number of prefixes, infixes or suffixes.

Piuma Paiwan	Stress	Gloss
piku	píku	'elbow'
qiʎas	qíʎas	'moon'
vitsuka	vitsúka	'stomach'
ʎavatsaq	ʎavátsaq	'horsefly'
ku-vuvu	kuvúvu	'my grandparents'
maʎə-l̩aɖuq	maʎəl̩áɖuq	'too long'
s-əm-u-kava	səmukáva	'to take off clothes'
kan-an	kánan	'place where one eats'
ɟavats-an	ɟavátsan	'muscle ache in legs'
in-ituŋ -an	initúŋan	'garment'
kaʎa-quɟaʎ-an	kaʎaquɟáʎan	'rainy season'

The stress patterns in Piuma Paiwan are generalized as follows: penultimate stress $[\acute{\sigma}\sigma]_{Prwd}$ and final stress subject to the rightmost monosyllabic root $[\acute{\sigma}]_{Prwd}$ or subject to schwa penult $[\sigma\ə\acute{\sigma}]_{Prwd}$.

Main stress in Piuma Paiwan falls on the penultimate syllable of a word, when the penult of the word does not have a schwa. If a word has a schwa in the penult, it will receive final stress. Diphthongs do not attract stress, which is the evidence for a Quantity Insensitive stress system. Secondary stress was not attested in polysyllabic prosodic

words of Piuma Paiwan. On the other hand, a schwa syllable can bear stress only when it is the final syllable of a word, and the word has another schwa in the penult.

To sum up, penult is the most prominent position for Piuma Paiwan stress, but the right edge of a prosodic word becomes the optimal position for stress among equal prominent schwas in the quality-sensitive stress system.

2.2 Stress patterns in the other Paiwan village dialects

A Paiwan word typically has a single primary stress in its elicitation form. Word stress usually falls on its penultimate syllable, when the word consists of suffixed forms. In prosodic words without any schwa penult, all the Paiwan village dialects investigated in the study share the same stress patterns. The statement of the stress patterns is general to the Paiwan village dialects of Sandimen and Mudan, and it applies to every possible prosodic word of these village dialects. The following data were drawn from the Mudan Paiwan village.

(3) Main stress in Paiwan: main stress in Paiwan falls on the final syllable only in the case of a monosyllabic prosodic word. Otherwise, main stress is on the penult.

a. Stress in Roots

Stress	Shape	Root	Gloss
σ́	CV	tú	‘burning charcoal’
σ́	CV́C	gáŋ	‘crab’
σ́	CV́V	váu	‘feminine name’
σ	CV́VC	ʌ́uaŋ	‘cattle’
σ́σ	CV́CV	píku	‘elbow’
σ́σ	CV́CVC	púnuq	‘brain’
σ́σ	CV́VCVC	qáuɭaj	‘dried-up fruit’
σ́σ	CV́CCVC	ʌ́amʌ́am	‘ginger’
σσ́σ	CVCV́CV	qarába	‘flat worm’
σσ́σ	CVCV́CVC	vaɭátsuk	‘woodpecker’

b. Stress in suffixed forms: main stress falls on the penult of a suffixed form.

Stress	Morpheme	Suffixation	Gloss
σ́σ	kan-an$_{suffix}$	kánan	‘place where one eats’
σσ́σ	vaik-aŋa$_{suffix}$	vaikáŋa	‘already left/gone’
σσ́σ	sa$_{prefix}$-ɭum-an$_{suffix}$	saɭúman	‘fragrance’
σσσ́σ	in$_{prefix}$-ituŋ-an$_{suffix}$	initúŋan	‘clothing’
σσσσ́σ	kaʌ́a$_{prefix}$-quɟaʌ́-an$_{suffix}$	kaʌ́aquɟáʌ́an	‘rainy season’

c. Stress in prefixed forms: main stress falls on monosyllabic roots, or it falls on the penult of disyllabic or longer roots.

Stress	Morpheme	Prefixation	Gloss
σσ́	pa_{prefix}-kan	pakán	'to feed'
σσσ́	pa_{prefix}-ki_{prefix}-kan	pakikán	'to feed (animals)'
σσσ́	ma_{prefix}-$pə_{prefix}$-tad	mapətád	'to dry (something)'
σσσ́	sa_{prefix}-ru_{prefix}-ŋuaq	saruŋuáq	'comfortable'
σσ́σ	mi_{prefix}-l̪ima	mil̪íma	'to wash hands'
σσ́σ	ku_{preix}-vuvu	kuvúvu	'my grandparents'
σσσ́σ	maʎə$_{prefix}$-l̪aɖuq	maʎəl̪áɖuq	'too long'
σσσ́σ	marə$_{prefix}$-sal̪aɟ	marəsál̪aɟ	'two companions'
σσσ́σ	pa_{prefix}-ki_{prefix}-ʎivak	pakiʎívak	'to take good care of'
σσσσ́σ	s_{prefix}-$əm_{infix}$-a-taihuku	səmataihúku	'to Taipei'

d. Stress in infixed forms: main stress falls on monosyllabic roots; otherwise, it is on the penult.

Stress	Morpheme	Infixation Form	Gloss
σσ́	k-$əm_{infix}$-an	kəmán	'to eat'
σσ́	k-$əm_{infix}$-ats	kəmáts	'to bite'
σσ́σ	k-$əm_{infix}$-al̪i	kəmál̪i	'to dig'
σσσ́σ	s_{prefix}-$əm_{infix}$-u-kava	səmukáva	'to take off clothes'
σσσσ́σ	k_{prefix}-$əm_{infix}$-asi-pana	kəmasipána	'to come from river'

A generalization of the occurrence of main stress in the Sandimen (三地門) and Mudan (牡丹) Paiwan village dialects is as follows: main stress falls on the final syllable only in the case of a monosyllabic prosodic word. Otherwise, main stress falls on the penult of a prosodic word (Prwd).

(i) … $σ_{prefix}$-$(C)_{stem}$-$σ_{infix}$ […σ́σ]$_{Prwd}$
(ii) … $σ_{prefix}$-$(C)_{stem}$-$σ_{infix}$ [σ́]$_{Prwd}$

Stress in Sandimen Paiwan and Mudan Paiwan differs from that in Piuma Paiwan in its not seeking out the most prominent vowel. In other words, stress patterns in the Sandimen and Mudan village dialects are quality-insensitive. Penultimate stress is the typical pattern in the Paiwan village dialects, while monosyllabic roots also bear stress when it occurs at the rightmost position in a prosodic word. Penultimate position is the optimal parameter for stress assignment in Sandimen Paiwan and Mudan Paiwan. In such a quality-insensitive system, stress always seeks out the penult in a prosodic word. Stress patterns in the Sandimen and Mudan village dialects are summarized as follows:

(4) Stress Patterns in Sandimen Paiwan and Mudan Paiwan
   a. Penultimate stress: […σ́σ]$_{Prwd}$
   b. Final stress subject to the rightmost monosyllabic root in a prosodic word.
   c. Prefixes and infixes are never stressed.

2.3 Historical implications

Earlier work on Proto-Austronesian (PAN) stress mainly focuses on the comparison and the reconstruction of the proto forms. Wolff (1993) has proposed that PAN roots had a stress contrast in the final two syllables of the root. According to him, there were two kinds of roots: those with a stressed penult and those with a stressed final syllable. By comparing stress patterns in Formosa and the Philippines, Wolff (1993) argues that in PAN the stress patterns fell on the penult of the root if it was long and on the final syllable of the root if the penult was short. In the current study, however, vowel length does not affect the assignment of phonological stress, and vowel quality, rather than vowel length, affects the assignment of phonological stress in Piuma Paiwan. Vowel length may be a phonetic realization or a correlate of stress, not necessarily to be a prerequisite to trigger phonological stress in Paiwan.

Although prefixes or infixes did not affect stress assignment in the cases of Paiwan, other types of affixation have been reported to affect PAN or Austronesian stress in earlier studies (Wolff 1993, Zorc 1993). There was the phenomenon of accent shift whereby the affixed form had the accentual pattern opposite to the pattern of the root, and some affixes dictate accent placement on derivations. Zorc (1993) classifies Austronesian stress and proposes that certain syntactic classes, such as pronouns, deictics, interrogatives, negatives, and numerals had accent on the final syllable. Furthermore, grammatical use of accent is proposed for verbs (in the imperative), for names or kin nouns and stative adjectives all of which have intonation falling on the final syllable, whereas the root word probably had accent on the penult. Syntactic classes in Paiwan, as far as I have observed, do not affect the assignment of word stress in the Paiwan village dialects. The metrical parameters for Paiwan stress have been proposed as follows: form syllabic trochees from right to left and end rule right. Final stress subject to schwa penult [σə́σ]$_{Prwd}$ was also proposed to account for the distribution of stress in Piuma Paiwan. Stress in the other Paiwan village dialects does not seek out the most prominent vowel.

Prosodic components, such as PAN stress or accent are not clear yet. The data drawn from Wolff (1993) have led to the generalization that PAN roots had a stress contrast in the final two syllables of the root. Yet, stress in Paiwan is generally position-dominated (either the penultimate or the final syllable). Wolff's (1993) proposal on PAN stress entails three assumptions: (i) second-right edge or right edge of PAN root is the optimal

position for stress; (ii) vowels of PAN root have long and short contrast; (iii) PAN stress is quantity-sensitive. Field data in the current study indicated that contrast of vowel length might be lost in Proto-Paiwan.

3. Phonetic stressed vowels

3.1 Methods

Paiwan has a quantity-insensitive stress. Three vowels **i**, **a**, and **u** in Paiwan were measured in terms of durations, pitch height, and intensity. None of the measured words were in sentence-final position. Words with schwa were excluded from the measurements, for the weak quality of schwa was supported not only by its phonetic nature but also by its more restricted distribution than the other vowels in Paiwan. Two experiments were conducted to examine the phonetic correlates of stress in Paiwan. In the first experiment, tokens from one Piuma Paiwan female speaker were recorded and sampled at 20,000Hz using the PCquirer analysis system. The speaker was considered the most typical in the Piuma village. A total of 30 elicitation tokens were measured. The stimulus was a Mandarin word, and the response was a Paiwan word. Words were repeated at least twice, allowing double measurements of the same word to be made. Multiple measurements of the same word were averaged. All of the measured words were in the form of CVCV, where C is either a voiceless stop or fricative, and V is **i**, **a** or **u**. The results were statistically analyzed by one-factor ANOVAs.

A CVCV Paiwan word typically has a stress falling on the first V. In other words, the first vowel of the measured word tends to have longer duration, higher pitch, or stronger intensity, if vowel duration, pitch, and intensity are phonetic correlates of stress in Paiwan. Many factors may influence vowel durations, such as vowel quality, postvocalic place of articulation, or speaking rate. The influence of the factors on vowel duration in English has been well documented, but the influence in Paiwan has not been studied at all. Informal studies on two-syllable Paiwan words (CVCV and CVCVC words) have indicated that syllable structure could affect vowel durations and that voiced fricatives and liquids might lengthen the durations of the following vowels. Vowels next to glides or voiced fricatives were excluded from the measurements, because it was difficult to determine the beginning or end of the vowels. In the first experiment, the factors of syllable structure and the voicing of consonants were controlled.

On the other hand, native speakers of Paiwan are not aware of their placement of stress until their kids manipulate wrong stress in their speech. Phonetic realization of Paiwan stress, if any, can further verify the existence of stress and the distinction between stress and unstressed vowels. Given that the data presented in the current study were collected from elicitation and that the natural patterns of the Paiwan sounds should be

preserved and retained, only minimal pairs for either phonemic or syllabic contrast were selected for comparison in the second experiment.

In the second experiment, a total of 48 elicitation tokens (8 words × 2 speakers × 3 villages) from six Paiwan speakers were selected for the measurements of vowel length, pitch height, and intensity. The six Paiwan speakers aged sixty to seventy were from the Paiwan villages of Sandimen (Stimul, 三地門), Piuma (平和), and Mudan (Sinvauɟan, 牡丹). Their native language was Paiwan, and most of the speakers spoke Japanese and Mandarin as well. For each village dialect (Sandimen, Piuma, Mudan), tokens were recorded from one male and one female speaker, who were considered typical by the other speakers in the villages. The informants participated in the recordings were recommended by the village residents and the chieftains of the villages. Other younger Paiwan informants refused to participate in the recordings, because they did not have confidence in the accuracy of their pronunciation. The following qualified words were found in the recorded voice data (see Appendix for dialectal variation, as Sandimen Paiwan does not have palatal /c/ or uvular stop /q/): **kaka** 'siblings', **qaqa** 'crow', **va** 'lung', **vava** 'wine', **vat** 'nutlet', **vu** 'intensities', **vuvu** 'grandparents', **vuc** 'squirrel'. The tokens were recorded in continuous elicitation, one repetition per item. A very short pause was inserted between items. None of the word-final vowels were also phrase-final. Tokens recorded from Mudan Paiwan speakers were excluded from figure representation due to sudden background noise. Only two words recorded from Mudan Paiwan speakers were clear enough for measurements: **kaka** 'siblings' and **qaqa** 'crow'. Due to the small size of the samples in each village dialect, the measurements and the results can only be preliminary and subject to refinement when a satisfactory number of recording tokens becomes available.

In both experiments, measurements included vowel durations, an estimate of the value of the first formant, the fundamental frequency at the midpoint of each vowel, and the intensity at the midpoint of each vowel. Vowel durations of the target vowels were measured from 300Hz bandwidth spectrograms, including the portion from the burst of the initial consonant to the cessation of high frequency energy. The results are given in §3.2.

3.2 Vowel duration and pitch results

Figure 1 summarizes the means and standard deviations for vowels in stressed and unstressed positions. In the figure the bars indicate the durations of the measured vowels, while the triangles indicate the pitch values of the stressed and unstressed vowels.

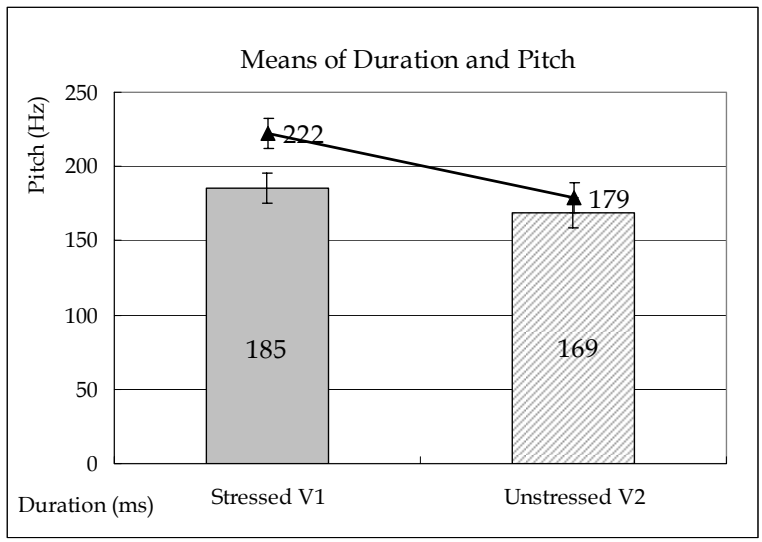


Figure 1: Means of vowel durations (ms) and pitch values for the stressed and unstressed vowels

Stressed vowels average 185 milliseconds (ms) while unstressed vowels average 169ms. The duration of a stressed vowel is 1.09 times that of an unstressed vowel. ANOVA analyses of variance have revealed that the effect of stress was not significant ($F[1,58]=3148$, $p>0.05$). Hence, stress may affect vowel durations in Piuma Paiwan, as stressed vowels have shown longer durations than unstressed vowels in the first experiment, but the effect is not significant. At this point, vowel duration may not be a strong correlate of stress in Piuma Paiwan.

On the other hand, stressed vowels average 222Hz pitch height while unstressed vowels average 179Hz at midpoints. ANOVA analyses of variance have shown that the effect of stress was significant ($F[1,58]=227$, $p<0.0001$). The results indicate that stress affects pitch values in Piuma Paiwan, and the effect is significant. Pitch is a strong correlate of stress in Piuma Paiwan.

As far as intensity is concerned, stressed vowels average 92.1dB while unstressed vowels average 91.5dB at midpoints. The difference between stressed and unstressed vowels is less than 1dB. ANOVA analyses of variance have shown that the effect of stress was not significant ($F[1,58]=1.27$, $p>0.05$). The results show that intensity may not be a strong correlate of stress in Piuma Paiwan.

Results from the second experiment are summarized in Figures 2 and 3. The comparison of vowel durations in the same phonetic context is illustrated in Figure 2, whereas the vowel durations of CV_1 syllable, the stressed syllable, are illustrated in

Figure 3. Due to the small size of the tokens, no statistical test was conducted here to show the significant difference between the groups. Each bar in the figures represents the group mean.

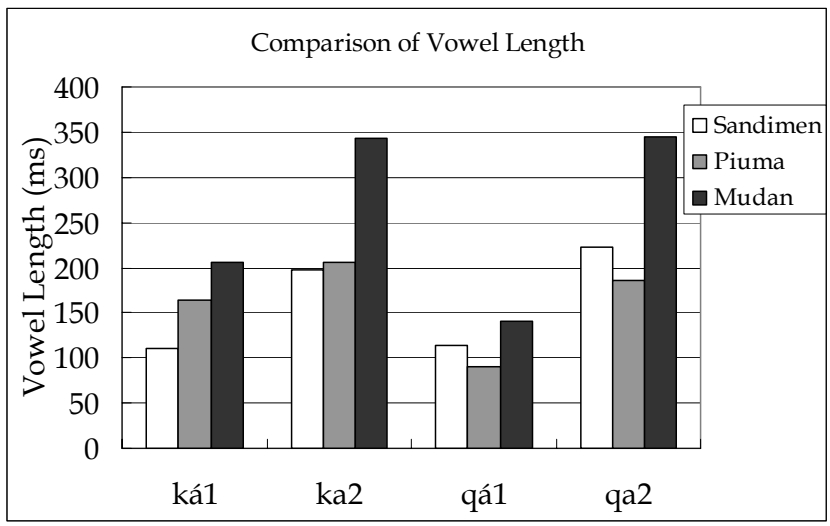


Figure 2: Comparison of vowel durations in Paiwan

As shown in the words **ká$_1$ka$_2$** and **qá$_1$qa$_2$**, CV_1 syllables in both words are stressed, but the vowels in stressed syllables are shorter, compared with the unstressed final syllables CV_2 in the same words. The pattern is rather consistent in the Sandimen, Piuma, and Mudan village dialects. The results indicate that the effect of final lengthening might be imposed on the realization of the unstressed final vowels. Results from the second experiment have shown that final syllables might be longer in the Paiwan village dialects, regardless of stressed or unstressed syllables.

As for the effect of syllable structure, vowels in open syllables tend to be longer than those in closed syllables. As shown in Figure 3, all the vowels in the examined CV_1 are stressed, but they apparently have various vowel durations. Vowel durations in the closed syllables '**vat**' and '**vut**' are shorter than those in the open syllables '**va**' and '**vu**' of Piuma Paiwan, and the open syllable '**va**' of Piuma Paiwan has the longest vowel duration. Nevertheless, vowel shortening in closed syllable was not found in the word pairs **va** and **vat** of the Sandimen village dialect, as shown in Figure 3. Vowel shortening associated with syllable structure, named Closed Syllable Vowel Shortening (CSVS) by Maddieson (1985), can be used as a cue to the syllabic constituency of a segment string. Many Paiwan words end with a CVC syllable. The phonetic pattern of CSVS was attested in Piuma Paiwan and thus provides some support for the internal

constituent of the CVC syllable in the Paiwan village dialect. On the other hand, internal vowel durations shown in Figure 3 indicate that low vowel **a** is not consistently longer than high vowel **u** in the same phonetic context. The high vowel **u** in the open syllable **vu** has longer vowel duration than the low vowel **a** in the syllable **va**, as shown in the tokens produced by the Sandimen Paiwan speakers.

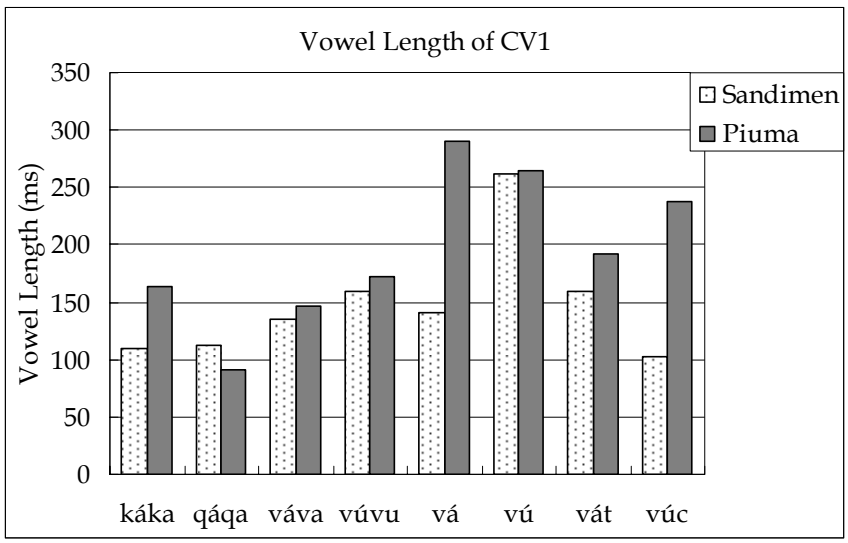


Figure 3: Durations of stressed vowels in Sandimen Paiwan and Piuma Paiwan

When the results from the first and second experiments are compared, it is clear that vowel duration may not be a strong correlate of stress in the Paiwan village dialects. Stress may affect vowel durations in Paiwan, but the effect is not significant. Yet, stress does affect pitch height of vowels. Pitch height is a strong correlate of stress in the Paiwan village dialects.

3.3 Phonetic correlates of stress in Paiwan

Let us consider whether the effect of final lengthening on duration obscures the effect of stress. When the quality of the preceding consonants and the effect of final-vowel lengthening were controlled, as found in the word **tatáqan** 'grindstone'[8] (**tatá?an** in Sandimen Paiwan), duration and pitch were measured. The vowel in the trisyllabic word is **a**, and the word ends with a closed syllable. Due to the noisy recording

[8] The word **tatáqan** (**tatá?an**) 'grindstone' is the only qualified trisyllabic word for the controlled condition in the recordings.

background in the field, some tokens were excluded from the measurements. Four tokens (one female Sandimen Paiwan speaker, two female Piuma Paiwan speakers, and one male Mudan Paiwan speaker) of the same word were selected for the measurements. Again, the speakers participated in the recordings were considered typical in the Paiwan villages. All the qualified tokens were recorded in elicitation, one repetition per item. None of the word-final vowels were also phrase-final. Vowel durations of the target vowels were measured from 300Hz bandwidth spectrograms, including the burst of the initial consonant to the cessation of high frequency energy. The fundamental frequency at the midpoint of each vowel was also measured. The results of the informal measurements are illustrated in Figures 4 and 5. In the figures, SF stands for Sandimen Female; PF1 stands for the First Piuma Female and PF2 the Second Piuma Female; MM stands for Mudan Male.

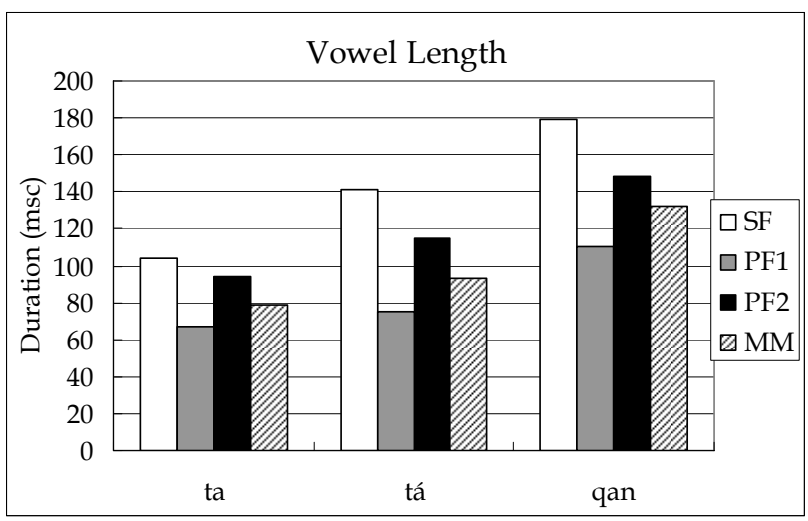


Figure 4: Vowel length in the word **tatáqan** (**tatáʔan**)'grindstone'

The stressed vowel in **tatáqan** (**tatáʔan**) 'grindstone' tends to have higher pitch values. Yet, durations of the final vowels were the longest among the measured tokens. On the other hand, stressed vowels have higher pitch than the unstressed initial vowels and the final vowels, as shown in Figure 5. Penultimate syllables may have higher pitch than the initial syllables due to stress effect, while final syllables may have longer duration due to their position-in-word. It seems that stress lengthening correlates with higher pitch (f0), whereas final lengthening of the unstressed vowels correlates with lower pitch.

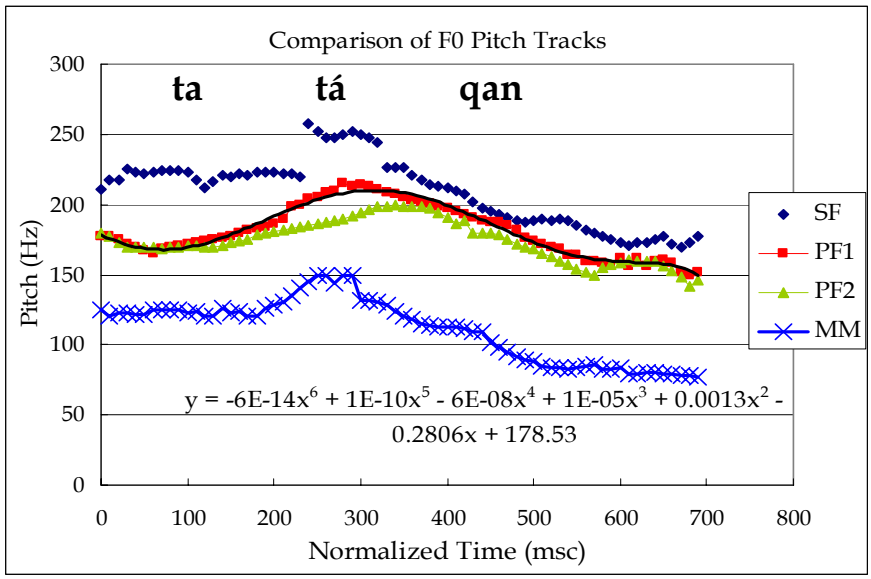


Figure 5:[9] Pitch tracks of the word **tatáqan** 'grindstone'

The examination of stressed vowels in the Paiwan village dialects indicates that phonetic correlate of pitch tends to be the prominence of stress. In other words, stressed vowels in the Paiwan village dialects tend to have higher pitch. Yet, final lengthening may occur to mask the phonetic correlate of vowel length.

Final lengthening is due to position-in-word, whereas higher pitch on the penultimate syllable is due to stress effect. Stress lengthening correlates with higher pitch, while final lengthening does not. The observations have a bearing on the issue of the phonetic correlates of stress in diverse languages. de Jong & Zawaydeh (1999) point out that the degree to which the prosodic effects will be manifested in a particular system is part of the linguistic convention which needs to be specified for a particular language. Prosodic systems are not stereotypical. In English, duration is a more effective cue to stress than intensity, and pitch is an even more effective cue than duration (Fry 1955, 1958). On the other hand, pitch accent languages such as Japanese use pitch as a correlate of stress to a greater extent than English (Beckman 1986). Laver (1994) investigated different typological lexical stress and has confirmed the dominant role of pitch in conveying stress patterns. Results from the current study have also shown that in Paiwan pitch is a more effective cue to stress than duration.

[9] The trend line added in Figure 5 was based on the pitch track of the token produced by the first Piuma female speaker (PF1). The gaps between the F0 pitch tracks due to the voiceless consonants shown in Figure 5 were discarded to make the F0 lines smooth.

Another finding from the investigation is the low pitch on the final unstressed vowels. The final unstressed vowel with longer duration and pitch drop provides some support for the Paiwan word as a phonological unit. The boundary of a Paiwan phonological word in elicitation is usually aligned with pitch drop.

4. Word-level accent in Paiwan

Paiwan has different prosodic representations from Mandarin and Taiwanese spoken in its geographically contiguous districts. Vowels originally long in Japanese may be stressed in Paiwan, which violates the general principles for stress assignment in the language. Japanese is a non-stress pitch accent language, while stress pattern in Paiwan is predictable in prosodic words. In Tokyo Japanese, it has been assumed that accent is not fixed in two- or three-syllable nouns, though accent assignment usually falls on the final vowel of the stem (or root) of an accented adjective or verb (cf. Haraguchi 1991). For instance, there are three classes of accented nouns: antepenultimate-accented, penultimate-accented and final-accented. The smallest unit in Japanese has a basic tonal pattern which may be schematized as 'LH (L)'. The only lexically distinctive property is the location of the fall from High to Low. The syllable after whose first mora the fall occurs is accented, whereas no fall occurs referred as unaccented.

Pitch accent in Paiwan also occurs in words. Accent attested in Paiwan words is word-level accent, and the words with accent include prosodic words in imperatives and pragmatic contexts. The distribution of word-level pitch accent was analyzed in terms of phonetic implementation in this section. There are a lot of factors that affect f0 timing (cf. Silverman & Pierrehumbert 1990, Prieto et al. 1995, Xu 1998, 2001, Myers 2003), and the factors controlled in the investigation of the word-level accent here are the contexts and the position in utterance, depending on the categories of the words.

In an isolated Paiwan prosodic word, stress is the only parameter to determine the alignment of peak prominence. A prosodic word with penultimate stress is illustrated in Figure 6. The token was recorded from a Piuma Paiwan female speaker in elicitation. Vertical dashed lines represent the timed f0 landmark with respect to syllables.

As shown in Figure 6, the word starts from the pitch around 200Hz, followed by a trough, presumably due to the voiced stop [d]. The pitch track line then goes up to 238Hz, the f0 peak, in the second syllable. A falling track line occurs in the third syllable, down to 151Hz at the end. Word stress falls on the second syllable of the word, and the f0 peak occurs in the second syllable. It is clear that word stress is realized as an f0 pitch peak. Note that the f0 peak does not occur at the beginning of the stressed syllable **dí**. Rather, it occurs around 52 milliseconds later than the starting point of the syllable.

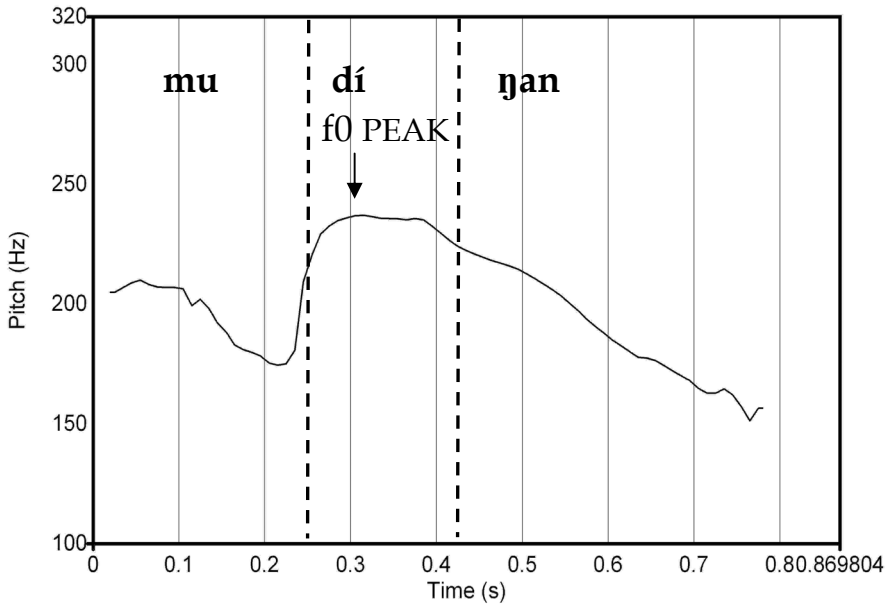


Figure 6: A pitch track of the prosodic word *mudiŋan* 'face'

When a prosodic word is placed in different discourse contexts, pitch accent may change either the f0 timing or the peak alignment in the prosodic word. Two major types of accent were investigated: imperative accent and emphatic degree accent.

4.1 Imperative accent

Imperative construction in Paiwan is formed by a vocalic morpheme *-u* following a verb stem, when the theme is an exclusive imperative construction. On the other hand, a verb stem is followed by the vocalic morpheme *-i* to form an inclusive imperative construction. In other words, Paiwan inclusive imperative is indicated by the vocalic morpheme *-i*, whereas exclusive imperative is indicated by the vocalic morpheme *-u*. Some examples of Paiwan exclusive imperative construction are given in (5). In the following examples, 'H' indicates a high tone, a phonetic pitch peak in the prosodic word.

As shown in (5a-c), imperative construction is marked by a low boundary tone when the vocalic morpheme is added to the consonant-final stems or vocalic stems ending with vowels other than **u**. The imperative words were recorded in isolation. It is very likely that the end of the word is also the end of an intonational phrase, which may result in the low boundary tone. The pitch peak is aligned with the stressed syllable, i.e. the penultimate syllable of the imperative words.

(5)	Verb Stem	Gloss	Imperative Verb	Gloss
a.	kán	'to eat'	kán-u H	'(You) Eat!'
b.	kiqíʎa	'to hide oneself'	kiqíʎa-u H	'(You) Hide!'
c.	kím	'to search for'	kím-u H	'(You) Look for!'
d.	qívu	'to speak'	**qivu-u** **H**	'(You) Say!'
e.	súpu	'to count'	**supu-u** **H**	'(You) Count!'

A pitch track of the imperative word **kán-u** '(You) Eat!' is illustrated in Figure 7. The vertical dashed line represents the timed f0 landmark with respect to syllables.

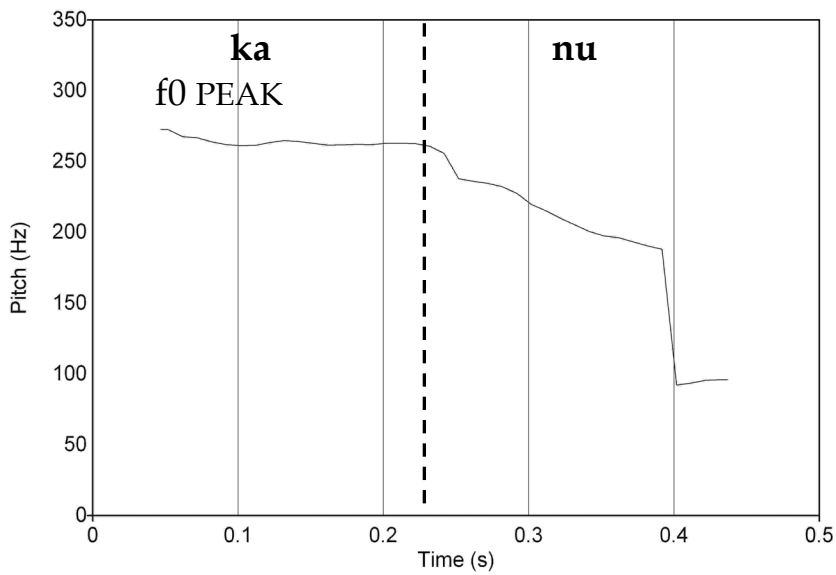


Figure 7: A pitch track of the word *kánu* '(You) Eat!'

As shown in Figure 7, the f0 peak occurs at the beginning of the stressed syllable **ká**, and the high flat pitch line in the first syllable is followed by a falling tone in the second syllable **nu**, also the final syllable of the imperative word.

However, when the imperative vocalic morpheme is added to vocalic stems ending with the same vowel **u**, the pitch peak is aligned with the right edge of the construction, i.e. the final syllable of the prosodic word, as shown in (5d-e). Imperative forms in (5d-e) differ from non-imperative forms in the occurrence of f0 peaks in the final syllable. The final syllables in the two imperative examples are not stressed, and they bear the high tone. For instance, the prosodic word **súpu** 'to count' has a stress on the first syllable **sú**, and the f0 peak in the word occurs in the syllable **sú**. When the imperative morpheme **-u** is added to the word to form **supu-u** '(You) Count!', the f0 peak occurs in the second syllable **pu**, the final syllable of the imperative form. A pitch track of the imperative form **supu-u** '(You) Count!' is illustrated in Figure 8. The vertical dashed line represents the timed f0 landmark with respect to syllables.

As shown in Figure 8, the f0 peak occurs in the second syllable **pu**, also the final syllable of the imperative word. Note that the peak does not occur at the beginning of the second syllable, around 85 milliseconds late.

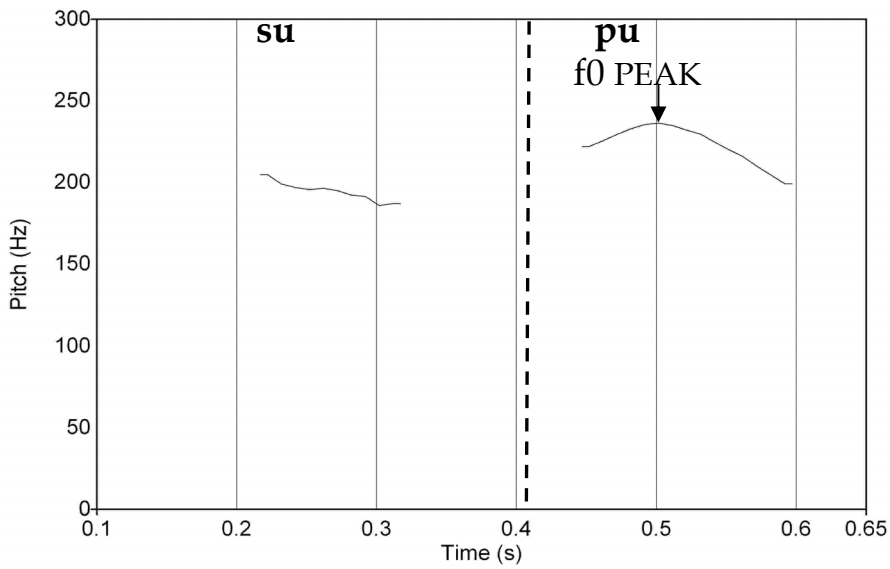


Figure 8: Imperative pitch accent in the word *supu* '(You) Count!'

The paradigm of Paiwan imperative construction is illustrated in (6). The data presented here were collected from Piuma Paiwan, in which penultimate schwa results in a final stress. In the imperative paradigm, pitch peaks occur in the stressed syllables when the vocalic morpheme is added to the consonant-final stems or vocalic stems ending with the vowel other than **u** and **i** respectively in exclusive and inclusive imperative construction. The alignment of the pitch peak with the stressed syllable indicates no

extra pitch accent occurs in the prosodic words, and the pitch peak is the phonetic realization of stress. On the other hand, when the imperative vocalic morpheme is added to stems ending with the identical vowel, pitch peaks always occur in the final syllable of the prosodic words.

(6)	Exclusive Imperative	Gloss	Inclusive Imperative	Gloss
a.	pasəɟám-u	'(You) Borrow!'	pasəɟám-i	'(We) Borrow!'
b.	pabərús-u	'(You) Spurt!'	pabərús-i	'(We) Spurt!'
c.	kaɭáva-u	'(You) Wait!'	kaɭáva-i	'(We) Wait!'
d.	ɟapəs-ú	'(You) Blow!'	ɟapəs-í	'(We) Blow!'
e.	ɖukúŋ-u	'(You) Stoop!'	ɖukúŋ-i	'(We) Stoop!'
f.	káɭi-u	'(You) Dig!'	**kaɭí-i**	'(We) Dig!'
g.	sənái-u	'(You) Sing!'	**sənaí-i**	'(We) Sing!'

Grammatical imperative final accent results in the pitch peak aligned with the final syllable. Accent occurs at the final syllable to distinguish a verb stem from an imperative verb, when the stem ends in the identical vowel with the imperative vocalic morpheme. The imperative morpheme does not form a long vowel with its preceding vowel in prosodic representation.[10] Some imperatives ending with a high tone is due to the realization of stress, when the vowels in the penultimate syllables are weak schwas.

Blust (2003) investigates the Thao language, another Formosan language, and proposes *vetative stress shift rule* in which the imperative suffix is stressed in vetative constructions when it occurs in consonant-final stems or vocalic stems which do not produce a diphthong. Blust (2003) claims that vetative stress shift is conditioned by a mixture of syntactic and phonological considerations. The patterns of vetative stress shift in Thao are somewhat similar to those of the Paiwan imperative. A few examples drawn from Blust's (2003) dictionary are given as follows.

(7)								
a.	/ata	tu	sakup-i/	[ata	tu	sakp-í]	'Don't catch it!'
b.	/ata	tu	pasiz-i/	[ata	tu	pasið-í]	'Don't put it back together!'
c.	/ata	tu	riri-i/	[ata	tu	reré]	'Don't seek revenge!'

The difference between Paiwan and Thao imperatives is the distribution of 'vetative stress shift', as termed by Blust (2003). In Thao, the *vetative stress shift rule* applies to

[10] Informal measurements of vowel durations have been done for the imperative data. Voice data from two Piuma Paiwan female speakers were examined. Imperative final vowels were not longer than the final vowels in non-imperative prosodic words in the same condition.

the whole imperative construction. The 'vetative stress shift', however, does not occur in all imperative constructions in Paiwan. Peak alignment with the final syllable of a prosodic word occurs only in sequences of two identical vowels across a morpheme boundary in Paiwan. When the imperative vocalic morpheme follows a consonant-final stem or vocalic stem ending in a vowel other than **u** or **i**, the vocalic morpheme is integrated into a well-formed prosodic word. Stress assignment occurs in the prosodic word.

Peak alignment with the final syllable of a prosodic word provides further strong evidence for the proposal of word-level pitch accent. The distinctiveness of pitch accent was attested in the production and perception of Paiwan speech. Some accented words are phonemic, in which case the alignment of peak prominence with the final syllable of the word is obligatory. Failure to implement prosodic rules may result in mispronunciation. Minimal pairs are given in (8). Utterance with imperative pitch accent is underlined and in bold. Again, 'H' indicates a high tone in the prosodic word.

(8)		Paiwan	Pitch Accent	Gloss
	a.	paisu	páisu H	'money'
		paisu (<paisu-u)	**paisu** H	'(excl. imperative) Pestle!
	b.	katsu (<kats-u)	kátsu H	'(excl. imperative) Bite!'
		katsu (<katsu-u)	**katsu** H	'(excl. imperative) Bring (it)!'
	c.	vənəl̥i	vənə́l̥i[11] H	'to buy'
		vənəl̥i (vənəl̥i-i)	**vənəl̥i** H	'(incl. imperative) buy!'

As shown in (8), the placement of the imperative accent plays a crucial role in the interpretation of the lexical forms. Exclusive imperative 'pestle', for instance, differs from 'money' only in its pitch accent. In the word **páisu** 'money', the high tone is

[11] The token was collected in the Sandimen village. In Sandimen Paiwan, a penultimate schwa can bear stress.

aligned with the penultimate stressed syllable, whereas the imperative high tone is aligned with the final syllable in the word **paisu** '(You) Pound with a pestle!' Listeners must catch the pitch accent to distinguish imperative 'bite' **kátsu** from imperative 'bring' **katsu**. And **vənə́l̪i** 'to buy' differs from **vənəl̪i** '(We) Buy!' in its pitch accent only.

4.2 Emphatic degree accent

Emphatic degree accent is attested in Paiwan discourse. Examples are given in (9) and (10). Underlined words in these examples were uttered with emphatic accent.

(9) A: a inu a ma-tsulutsulu, aku-sun a v-ən-ətsavətsa a ʔivu
where burn-Reduplication why-you lie-Affix to tell
'Where does it burn? Why are you telling a lie?'
B: **matsulu**, **matsulu**
burn burn
'It DOES burn! It DOES burn!'

(10) A: madudu ti Viguŋ ?
mad Viguŋ
'Is Viguŋ mad?'
B: ui, **madudu** ti Viguŋ
yes mad Viguŋ
'Yes, Viguŋ is VERY MAD.'

Emphatic degree accent can be found in many other languages. Laver (1994) argues that the function of emphatic stress is to call the listener's attention to a given syllable or word with greater insistence. A paralinguistic effect of emphatic accentuation can also be to signal the degree of intensity felt by the speaker about the topic under discussion. Emphatic accent in Paiwan is also used to signal the degree of intensity. For instance, 'very old' has longer duration and higher f0 than 'old'. There is no degree adverb 'very' or 'extremely' in Paiwan lexeme. The way to denote the meaning of 'very' is either to reduplicate stems or to manipulate prosodic prominence. In the case of *vuɭuŋvuɭuŋ* 'old', already a reduplicated form, the distinction between 'old' and 'very old' is hence imposed on prosodic elements.

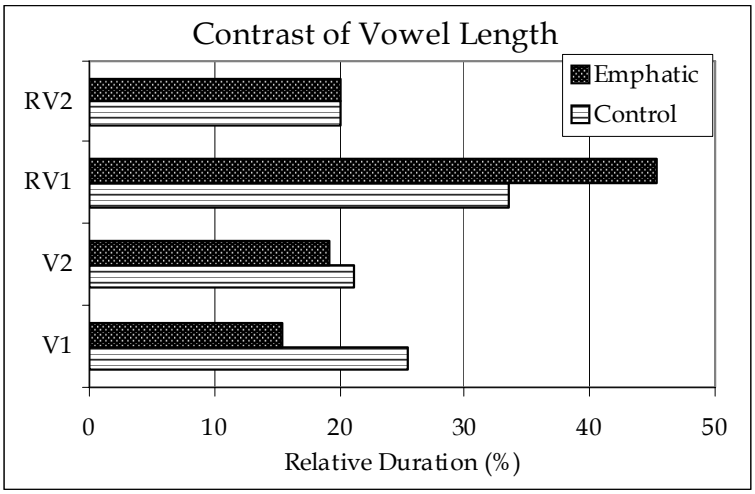


Figure 9: Relative duration of vowels in *vuɭuŋvuɭuŋ* 'old/very old'

Emphatic accent results in longer duration of the reduplicated vowels (RV), as shown in Figure 9. Emphatic accent assignment is correlated with the penultimate position, and the reduplicated vowel RV1 at penultimate position has the most significant lengthening, around 1.35 times that of an unaccented vowel. Yet, emphatic accent does not lengthen the relative duration of the other vowels in stems. The result indicates that emphatic accent is correlated with word stress at penultimate position.

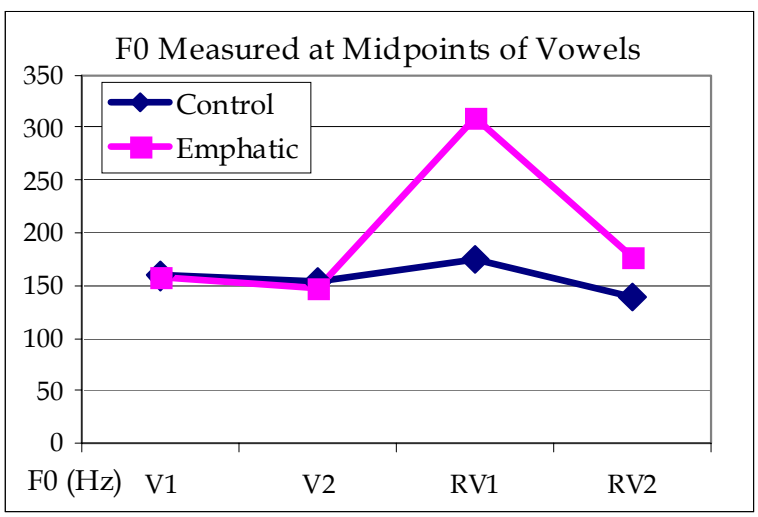


Figure 10: F0 contrast of *vuluŋvuluŋ* 'old/very old'

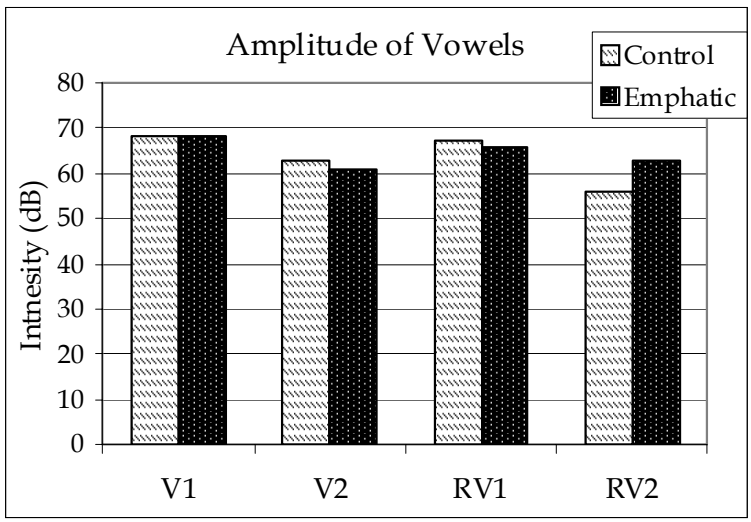


Figure 11: Intensity contrast of *vuluŋvuluŋ* 'old/very old'

As shown in Figure 10, tokens with emphatic accent have higher pitch than the control tokens. Again, higher pitch was attested in the penultimate position. On the other hand, amplitude is not correlated with accentuation, as shown in Figure 11. Emphatic vowels do not have greater intensity than the control vowels. The result indicates intensity may not be a phonetic correlate of emphatic accent. Pitch tends to be a robust cue to word-level accent in Paiwan.

In summary, emphatic accent signals both degree of intensity and distinctive levels of degree. Emphatic accent in Paiwan is realized as higher pitch and longer duration. Intensity is not a correlate of emphatic accent. Based on the phonetic realization of emphatic accent in Paiwan, it is reasonable to propose that a prosodic word in Paiwan associated with an emphatic accent has greater prosodic prominence (longer duration and higher pitch) than a prosodic word which is not associated with an emphatic accent.

5. Conclusion

In the present study, phonetics of word-level prosody in Paiwan has been investigated. Word-level stress, imperative and emphatic accent were examined to support the argument that phonetic representation plays a role in the documentation of phonology. Studies on sound patterns (Keating 1990, Pierrehumbert 1990, Cho & Ladefoged 1999) have also revealed that there are language specific phonetic rules which must be part of the grammar of each language. The categorical phonetic representation could be the output of the phonology, or at least, part of the grammar of the Paiwan language.

Penult is the most prominent position for Piuma Paiwan stress, but the right edge of a prosodic word becomes the optimal position for stress among equal prominent schwas in the quality-sensitive stress system in Piuma Paiwan. Stress patterns in Sandimen Paiwan and Mudan Paiwan are quality-insensitive. Penultimate stress is the typical pattern in Sandimen Paiwan and Mudan Paiwan, while monosyllabic roots also bear stress when it occurs at the rightmost position in a prosodic word. Penultimate position is the optimal parameter for stress assignment in the Sandimen and Mudan village dialects.

Phonetic correlates of Paiwan stress have been examined. Final syllables might be longer in Paiwan, regardless of stressed or unstressed syllables. Paiwan speakers in the villages tend to exhibit final lengthening effect. When the quality of the preceding consonantal segments and the effect of final-vowel lengthening were controlled, stressed vowels have higher pitch than the unstressed initial vowels and the final vowels, and the stressed vowels at the penultimate syllables are longer than the unstressed vowels at the initial syllables. Stress lengthening correlates with higher pitch, whereas final lengthening of the unstressed vowels correlates with lower pitch. Final lengthening is due to position-in-word, whereas higher pitch on the penultimate syllable is due to stress effect. Stressed syllables in the examined data always have higher pitch than unstressed syllables, and pitch height tends to be a robust cue. On the other hand, the boundary of a phonological word in elicitation is usually aligned with pitch drop. Vowel duration may not be a strong correlate of stress in Paiwan. Stress may affect vowel durations in Paiwan, but the effect is not significant. Yet, stress does affect pitch height of vowels.

Fry (1955, 1958) investigated the acoustic and perceptual correlates of lexical stress in English noun/verb word-pairs. Following his hierarchy, duration is a more effective cue to stress than intensity, and pitch is an even more effective cue than duration. In the present study, it has been found that the position in a prosodic word may determine the vowel length of a syllable, for instance, phonetic final lengthening in the Paiwan village dialects. On the other hand, stressed syllables consistently have higher pitch than unstressed syllables. Results from the experiments have also shown that pitch is a more effective cue to stress than duration in Paiwan.

Paiwan words with accent include prosodic words in imperatives and emphatic contexts. It has been found that phonetic implementations of high and low tones are important indices for word-level pitch accent of Paiwan. When a prosodic word is placed in different contexts, pitch accent may occur to change either the f0 timing or the peak alignment in the prosodic word. Imperative accent occurs at the final syllable to distinguish a verb stem from an imperative verb, when the stem ends in the identical vowel with the imperative vocalic morpheme. On the other hand, a prosodic word associated with an emphatic accent has longer duration and higher pitch than a prosodic word which is not associated with an emphatic accent. Emphatic accent in Paiwan is

correlated with word stress at penultimate position, and it is realized as higher pitch and longer duration.

Word-level accent in Paiwan entails semantic and pragmatic denotation. Yet, much more information about the traditional culture of Paiwan or the interaction between the speakers has been revealed in narrative, discourse, and conversation. Prosody must be a primitive device in Paiwan speech. Word-level prosody or prosodic variation in Paiwan was best modeled in terms of f0 realization.

Appendix: Paiwan word list used as a basis for the recordings and the measurements of stressed vowels

Paiwan village dialects / Gloss	**Sandimen**	**Piuma**	**Mudan**
'siblings'	kaka	kaka	kaka
'crow'	ʔaʔa	qaqa	qaqa
'lung'	va	va	va
'wine'	vava	vava	vava
'nutlet'	vat	vat	vat
'intensities'	vu	vu	vu
'grandparents'	vuvu	vuvu	vuvu
'squirrel'	vut	vuc	vuc

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排灣語字詞層次韻律的語音學探究

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本篇論文調查原住民語言字詞層次韻律的語音關聯因素，以佐證語音表述在音韻紀錄過程中扮演舉足輕重角色的論點。平和排灣語具有受音質影響的重音系統，外圍的母音如 /i/, /u/, /a/ 等比央元音更適合重音，主要的重音落在最響亮的元音上。然而，其他排灣語方言中的央元音卻能持有重音。另一方面，祈使調性影響語音音高對齊最後音節。重音節的母音比非重音節的母音具有較高的音高，而語音音高爲排灣語字詞層次重音與韻律特點方面較爲明顯的關聯因素。研究結果顯示，語音基頻的變化爲探究排灣語字詞層次韻律的最佳模式。

關鍵詞：語音學，排灣語，字詞層次韻律