

INITIAL CONSONANT VOICING PERTURBATION OF THE FUNDAMENTAL FREQUENCY OF ORAL VOWELS AND NASAL VOWELS: A CONTROVERSIAL CASE FROM BAN DOI PWO KAREN

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Abstract

This paper aims to analyze the acoustic characteristics of initial consonant voicing perturbation of the fundamental frequency of oral vowels and nasal vowels of Ban Doi Pwo Karen. Three age groups of informants were selected: over-sixty years old (>60), middle aged (35-45), and under-twenty years old (<20). The acoustic analysis method was employed to analyze the mean vowel duration (msec), mean vowel amplitude (dB), and mean vowel fundamental frequency (Hz). The results show that voiceless initial consonants tend to cause a lower fundamental frequency than that of the voiced initial consonants. This has excited controversy concerning the tonogenesis theory of initial voicing perturbation on vowels. However, it was later found that the vowels followed by voiceless initial consonants were breathy and it was the voice register of vowels that caused the low fundamental frequency values. In contrast to other studies, the nasal vowels were not always higher in fundamental frequency when compared to oral vowels. In all age groups, nasal vowels following

either voiceless or voiced consonants were found to be higher in fundamental frequency than oral vowels, except in the younger age group where the fundamental frequency of nasal vowels following voiced consonants was lower than that of the oral vowels following voiced consonants.

1. Introduction

According to linguistic classification (Grimes 1988), the languages spoken in Southeast Asia (SEA) can be grouped into five language families: Tai-Kadai (e.g. Thai); Miao-Yao (e.g. Miao, White Hmong); Sino-Tibetan (e.g. Chinese, Burmese); Austroasiatic or Mon-Khmer (e.g. Vietnamese, Mon, Khmer); and Austronesian (e.g. Malay, Javanese). The languages in these five families contain 3 main variations and are classified as the following: tonal languages (e.g. Thai, Chinese); non-tonal languages (e.g. Malay, Indonesian); and register languages (e.g. Chong, Mon). The distinctive feature of Tai-Kadai, Miao-Yao and Sino-Tibetan is tone. In contrast, most of the Mon-Khmer and Austronesian languages are non-tonal languages. At present, however, a number of non-tonal languages and register languages, such as some of the languages of New Caledonia in the Austronesian family and some Khmer dialects in the Mon-Khmer family, have been found to have changed from a stage of tonelessness to that of a tonal language. Some of the present tonal languages have also been found to have shifted their number of tones, that is to say, increasing the number of tones or decreasing the number of tones. This process of transformation is widely discussed as tonal evolution or the tonogenesis theory (Matisoff 1973).

In the year 1954, Haudricourt (1954) claimed that the Vietnamese language,

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which is tonal, had derived its tones from its non-tonal ancestral language. Therefore, he proposed that Vietnamese should be classified as a language in the Mon-Khmer family, not as it had previously classified, Sino-Tibetan. He argued that the main influences causing tone birth in the Vietnamese language had been the loss of initial and final consonants (See Table 1). Since then, Haudricourt's proposal has been broadly verified by linguists (Matisoff 1973, Maddieson 1984, L-Thongkum 1988, L-Thongkum et al. 2007, Thurgood 2007, etc.). Following this, others have proposed new influences that give birth to tones, for instance, the influence of the high-low dimension of vowels. Up to the present, linguists have discovered the various influences of consonants and vowel quality on the tonal evolution of the five Southeast Asian language families. These influences are; 1. Internal factors, (i) monosyllabication (ii) initial consonants (iii) vowel quality (iv) final consonants, and 2. external factors. Both internal and external factors have been claimed, seemingly, as universal phenomena.

Data from published studies proves SEA languages to have developed tones by a similar influence of consonants and vowels. The most established factor causing tone birth and development is initial consonant voicing; the voiced consonant changing to a voiceless consonant causing a low pitch or low tone in the later state. This is accepted to be a universal phenomenon by linguists studying SEA languages. However, an uncommon phenomenon has emerged from a dialect of Cantonese, T'ientsin, in which a high tone was found to have developed from an initial voiced consonant. This was reported in 1977 (Li 1977). In the Pwo Karen of Ban Doi,

Chiangrai, the identical phenomenon seems to be appearing in some words. It has been observed that an initial voiceless consonant has initiated a lower tone, while a voiced initial consonant has initiated a higher tone. This corresponds to what had been found in T'ientsin. Therefore, the objective of this study is to attest to the fundamental frequency behaviour of vowels influenced by initial consonant voicing in Ban Doi Pwo Karen. This study intends to investigate pitch behaviour in the vowels following voiceless and voiced initial consonants, i.e. to investigate whether or not the voiceless consonant induces a high pitch, while the voiced consonant induces a low pitch.

2. Literature review

Tonogenesis is the study of tone evolution or tone development in languages, especially in Southeast Asian languages. Prior to linguistics publishing linguistic results, many comparativists tried to reconstruct a proto-language to demonstrate that languages may form more contrastive pitches—that is, tones—through changes in the initial and final consonant features in their parent languages. This concept was first introduced by Przyluski (1924). A classical model of tonal evolution has been proven in the Vietnamese language by Haudricourt (1954) and has later been clarified by Matisoff (1973).

According to Table 1, the Vietnamese language in the early 6th century was a non-tonal language. Its syllables during this period were of (i) the open type, ending in a vowel /*-Ø/ or a nasal consonant /*-N/, and (ii) the closed type, ending in a fricative /*-h/ or a glottal stop /*-ʔ/. There were, in addition, two types of voicing distinction for initial consonants:

voiceless /p-/ and voiced /b-/. The loss of final consonants, /*-N/, /*-h/, /*-ʔ/, caused phonologically distinctive pitches or tones to emerge, namely level, falling and rising tones, as shown in Table 2.

By the end of the 12th century, the number of tones had increased to six through the loss of initial consonant voicing, as shown in Table 3. As the voiced initial consonants lost their voicing, /*b-/ > /*p-/, low and high tones emerged to avoid homophones. Tones emerged to replace consonant voicing and to differentiate word meanings. That is to say, when /*p-/ became /p/, a high tone resulted, and when /*b-/ became /p/, a low tone resulted.

The study of tonal evolution or tonogenesis has developed into a long progression, following the statement of the theory of consonant effect on the development of contrastive tones in the Vietnamese language.

Recently, Thurgood (2007) revised the model of Haudricourt (1954); explaining that pitch assignment occurs not from the consonant-based account but from the laryngeal-based or voice quality. This is due to instability in assigning pitch to the syllable from initial consonant types and final consonants.

In the case of initial consonants, it is argued, it is not Haudricourt's initial consonant types but the voice quality, breathy voice, tense voice and clear voice, that assigns pitch to the syllable. Mostly, a breathy voice induces low pitch, a tense voice high pitch and a clear voice mid pitch.

Considering final consonants, laryngeal features and final consonants are considered to give birth to pitch contour.

Glottal fricatives, /*-h/ or glottal stops, /*-ʔ/ alone are not the primary cause of falling or rising pitch but abrupt glottal stops [-ʔ abrupt] and [-h nonbreathy] relate to the raising of pitch or to a high pitch and a creaky glottal stop [-ʔ creaky] and a breathy final -h [-h breathy] relate to the lowering of pitch or a low pitch (Thurgood 2007).

In short, linguists have become aware of many universal phenomena which are thought to give birth to tones: 1. internal factors, (i) monosyllabicization (ii) initial consonants (iii) vowel quality (iv) final consonants, and 2. external factors.

2.1 Internal factors

2.1.1 Monosyllabicization

According to Matisoff (1973), languages whose basic syllable structures are monosyllabic in form are likely to develop tones. Most of the words in a language consist of stressed and unstressed syllables. An unstressed syllable tends to drop more than a stressed one (Thach 1999). This may possibly result in the creation of monosyllabic words and even bring homophones into a language. However, languages create tones to distinguish word meanings and also to avoid having homophones. Several studies have regarded monosyllabicization as the source of tone birth in the five language families of SEA (Henderson 1982, L-Thongkum 1984, Matisoff 1973, Teeranon 2008, Thach 1999, Thurgood 1999). Table 4 examines monosyllabicization in the Kiengiang Dialect of the Khmer language. In the case of the unstressed syllable, the first syllable of each word tends to drop and may result in monosyllabic words.

Table 1 Tonal development of the Vietnamese language in the early 6th century (non-tonal)

		Final consonants		
		<i>/*-Ø/, /*-N/</i>	<i>/*-h/</i>	<i>/*-ʔ/</i>
Initial consonants	Voiceless <i>/*p-/</i>	pa, paN	pah	paʔ
	Voiced <i>/*b-/</i>	ba, baN	bah	baʔ

(adapted from Haudricourt 1954 and Matisoff 1973)

Table 2 Three tones of the Vietnamese language around the 12th century

		Tones		
		Level	Falling	Rising
Initial consonants	Voiceless <i>/*p-/</i>	pa	pa	pa
	Voiced <i>/*b-/</i>	ba	ba	ba

(adapted from Haudricourt 1954 and Matisoff 1973)

Table 3 Six tones in the Vietnamese language by the end of the 12th century

Tones	Level	Falling	Rising
<i>/*p-/ > /*p-/ > High tone</i>	pa	pa	pa
<i>/*b-/ > /*p-/ > Low tone</i>	pa	Pa	pa

(adapted from Haudricourt 1954 and Matisoff 1973)

Table 4 Monosyllabicization in the Kiengiang Dialect of the Khmer language

Standard Khmer		Kiengiang Dialect	Meaning
cipcra:m	>	cra:m	‘to chop’
cangkra:n	>	kra:n	‘kitchen’

(adapted from Thach 1999: 84)

Table 5 A model of the influence of initial consonants on the development of tone

Proto-language, Non-tonal language		Non-tonal language		Tonal language
*pv	>	pv	>	p [́]
*bv	>	bv	>	p [̀]

Linguists such as Abramson (2004), Brunelle (2005), Matisoff (1973), and Michaud (2012) have also revealed that monosyllabicization results in tonal contrast across Southeast Asian language families.

2.1.2 Initial consonants

One of the most documented studies of tonal evolution concerns the influence of initial consonants on the development of tones. An illustration of the influence of initial consonants on the development of tones in SEA can be found in Table 5. Symbol ‘p’ represents a voiceless initial consonant, ‘b’ represents a voiced initial consonant, ‘v’ represents a vowel, /`/ is a low tone, and /´/ is a high tone.

Table 5 shows a loss of initial contrast and refers to the original initial consonants in the ancestral language (Proto-language). When the voicing distinction of the initial consonant in the Proto-language is lost, a higher tone /´/ seemingly appears in words formerly beginning with Proto-voiceless initial consonants as compared with words beginning with proto-voiced initial consonants accepting the result of the lower tone /`/.

Matisoff (1973) often refers to examples from the Tai-Kadai language family. One of these, the Thai language, is depicted in Table 6:

Another interesting case of the influence of initial consonants on tone birth is found in the Khmer language. The Phnom Penh Khmer was discovered for the loss of its cluster /-r-/ in /Cr-/, which also causes a falling-rising tone -- as in Table 7:

Hence, the influence of initial consonants causing tone birth has been proven in the five language families of SEA (Diffloth 1980, Erickson 1975, Haudricourt 1954, Li 1966, L-Thongkum 1984, Maddieson 1984, Maran 1973, Sun 2003, Teeranon 2008, Thurgood 1999).

2.1.3 Vowel quality

2.1.3.1 Voice register of vowels

Register is phonologically defined as a prosodic system (Henderson 1952), a contrast between phonation types. For example, the modal voice vowel and the breathy voice vowel in the Suai language spoken in Thailand:

Modal voice vowel

/lu:/	‘to howl’
/lu:m/	‘a mouthful’

Breathy voice vowel

/lɯ:/	‘thigh; the lap’
/lɯ:m/	‘to gobble chunks of food’

(adapted from Abramson, L-Thongkum, Nye 2004: 148)

Phonetically, register is called phonation type; it describes a cluster of laryngeal and supralaryngeal activities, one property of which may be dominant and the rest secondary. The term register is generally understood to mean a ‘register complex’, one property of which may be dominant and the rest secondary. The complex of phonetic characteristics typically includes such features as phonation type, pitch, vowel quality, vowel length, loudness and

perhaps others (Abramson, Thongkum, and Nye 2004: 147).

The register of vowels is regarded as the transcending stage (or middle point) for SEA non-tonal languages changing to tonal ones. Apparently, an example is derived from the Mon-Khmer language family dialects -- Khmu (Premssirat 2003).

According to Table 8, the Eastern Khmu dialect retains its voicing distinction of initial consonants, whereas dialect 1 of Western Khmu shows the register distinction of vowels. However, dialect 2 and dialect 3 of Western Khmu drop both initial voicing distinction and the register of vowels. With the loss of these two features, dialect 2 has now substituted low tones.

Until recently, only two language families -- Mon-Khmer and Austronesian -- have reportedly given birth to tones from the influence of vowel registers (Edmondson and Gregerson 1993, Henderson 1982, L-Thongkum 1988, 1989, 1990, Thurgood 1993, 1996, 1999).

2.1.3.2 High and low vowel dimension

In Southeast Asian languages, high vowels, e.g. /i/, have a higher pitch than low vowels, e.g. /a/, in non-tonal languages such as Malagasy (Whalen and Levitt 1995), an Austronesian language; in register languages such as Paroak (Watkins 2002), a Mon-Khmer language; and in tonal languages such as Thai (Mohr 1971, Zee 1980, Bunphan et al. 1982, Svantesson 1988, Rose 1997). All of the findings conclude that high vowels cause a higher fundamental frequency than that of low vowels.

However, Lehiste (1970) and Teeranon (2008) have revealed that the influence of initial consonants on the following vowels is much greater than the effect of the voice register of the vowel itself. It can be inferred that after the monosyllabization process or the change of syllabic structure to the monosyllable (Matisoff 1973), tones occurred as the voicing states of initial consonants influenced by the pitch of the following vowels, not higher and lower pitches within the vowels.

2.1.3.3 Vowel length

Hu, a language of the Mon-Khmer family, has been confirmed to have 2 tones, i.e. high tone vs. low tone which developed from the loss of vowel length. According to Table 9, the ancestral language of Hu (Proto-Palaungic) had both short vowels and long vowels. In the middle stage of Hu tonal evolution, the short vowels remained short but the long vowels began to lose their length. Following this, the new short vowels merged with the original short vowels. To compensate for the loss of vowel length, two tones have developed in Hu as shown in Table 9. (Diffloth 1980, Svantesson 1991).

Over the past 20 years, the birth of tones in many minority languages of the Mon-Khmer (Diffloth 1980, Svantesson 1991) and Sino-Tibetan language families (Sun 2003) have been found to indicate this type of influence. Recently, SEA languages such as Tai-Kadai, Miao-Yao, and other unmentioned categories, have developed tones through the loss of vowel length (L-Thongkum et al. 2007).

Table 6 The influence of initial consonants on tones in the Thai language.

Proto-Tai		Ancient Thai		Modern Thai	Meaning
*hmaa	>	hmaa	>	mǎa	‘a dog’
*maa	>	maa	>	maa	‘to come’

(adapted from Robinson 1994: 16)

Table 7 The lost of cluster in the Phnom Penh Khmer

Standard Khmer	Phnom Penh Khmer	Meaning
pram	p ^h eam	‘five’
triw	t ^h īw	‘correct’

(adapted from Guion and Wayland 2004: 1)

Table 8 The loss and the replacement of register distinction in Khmu dialects

Non-tonal language	Register language	Tonal language		Meaning
Eastern Khmu	Western Khmu Dialect 1	Western Khmu Dialect 2	Western Khmu Dialect 3	
bu:c	pɯ:c	p ^h ù:c	pù:c	‘fermented rice’
bok	pɔk	p ^h òk	pòk	‘to cut the trees’
bu:m	pɯ:m	p ^h ùm	pùm	‘to chew’
jaŋ	cəŋ	c ^h àŋ	càŋ	‘to weigh’
gla:ŋ	kla:ŋ	k ^h là:ŋ	klâ:ŋ	‘stone’

(adapted from Premssirat 2003: 25)

Table 9 The loss of vowel length in the Hu language

Proto-Palaungic				Hu	Meaning
*yam	>	*yam	>	yám	‘to die’
*yaam	>	*yam	>	yàm	‘to cry’

2.1.4 Final consonants

The influence of final consonants on the development of tones is widely observed in vowels preceded by a glottal stop consonant /*-ʔ/, including those headed by a glottal fricative consonant /*-h/. The loss of /*-ʔ/ tends to develop into a higher tone than those preceded by /*-h/. This phenomenon is often found in Middle Chinese (Hombert et al. 1979; Sagart 1993). Jingpaw spoken in Myanmar (Maran 1973) and Usat which is an Austronesian language spoken in Hainan (Thurgood 1996), and so forth.

However, not all languages conform to this hypothesis, for instance, in Eastern Chamic languages (Phu Van Han et al. 1992; Thurgood 1993) and some dialects of Tibetan (Mazaudon 1977; Sun 2003), the loss of the final /*-ʔ/ causes a low tone. As stated in Thurgood (2007) laryngeal features and final consonants are considered to give birth to pitch contour, so it is not only the final consonants that play a major role in pitch but also the phonation types of the vowels. This corresponds to the results found in L-Thongkum (1989, 1990) where it was pinpointed that the voice register of vowels plays a major role in causing tone birth.

Above all, the influence of final consonants, proven and verified, appears universally as a common phenomenon in SEA languages (Lohde 2003, Thavisak 2001, Watkins 2002).

2.2 External factors

The external factor, or language contact, is the only factor unlikely to be attested to within the frame of the tonogenesis theory.

According to Matisoff (1973), the Chinese language is the only true tonal language in the whole of SEA. The Chinese language, through its own internal factors, has developed its tones. In other words, tones did not emerge out of language contact. On the other hand, Tai-Kadai, Miao-Yao and the Austronesian language families have been claimed to have developed tones by interweaving parts from internal factors with language contact.

A number of observations have also been made by Thurgood (1996, 1999). In Western Cham, an Austronesian Language, tones have developed following influence from the Khmer language and Eastern Cham or Phan Rang Cham is transforming into a tonal language through the influence of Vietnamese. Additionally, the Chamic language which is known as Usat, a language of Hainan, has given birth to tones with the presence of the Chinese language.

3. Methodology

3.1 Context and language

This research was conducted at Ban Doi (Doi Village), Tambon Chokchai (Chokchai Sub-district), Amphoe Doi Luang (Doi Luang District), Chiang Rai Province, Thailand. Pwo Karen is the main language spoken by the villagers. The approximate population is 693 (356 males and 337 females). According to the phonological study, the sound system of Pwo Karen of Ban Doi is as follows (See Table 10 and Table 11):

Synchronic analysis reveals that there are 4 tones in the smooth syllables, high, mid, rising and low. The other 2 allotones are in the checked syllables, low?, and high?.

Table 10 Pwo Karen of Ban Doi consonants

	Places of articulation	Bilabial	Labio-dental	Alveolar	Palatal	Velar	Glottal
Manners of articulation							
Stop	voiceless unaspirated	p		t	c	k	ʔ
	voiceless aspirated	ph		th	ch	kh	
	voiced	b		d			
Fricative	voiceless		f		ʃ	x	h
	voiced					ɣ	
Nasal		m		n		ŋ	
Approximant		w			j		
Lateral				l			

Table 11 Pwo Karen of Ban Doi vowels

	Front	Central	Back
High	i	ɨ, ɨ̃	u, ʊ̃
Mid	e, ẽ	ə, ẽ̃	o, õ
Low	ɛ, ẽ̃	a, ã̃	ɔ, ɔ̃

/ai, au, ui, iə, ia, əu, ɔi, ɨ̃a, əi/

Table 12 Mean duration values, Standard deviation (SD) and *t-test* of oral vowels and nasal vowels in the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20)

Age group	Oral vowels (msec)			Nasal vowels (msec)		
	Voiceless onset	Voiced onset	<i>t-test</i> result (p)	Voiceless onset	Voiced onset	<i>t-test</i> result (p)
>60	224.86 SD = .73	273.89 SD = .77	.002	287.96 SD = .99	453.35 SD = .94	.000
35-45	288.50 SD = .67	329.50 SD = .89	.002	271.11 SD = .87	309.98 SD = .75	.002
<20	327.48 SD = .92	343.34 SD = .71	.045	231.73 SD = .90	232.05 SD = .87	.200

3.2 Wordlist

The wordlist used to attest to the influence of voiceless and voiced initial consonants followed by oral vowels contains 16 words; that is 8 words for voiceless initial consonants and 8 words for voiced initial consonants. Voiceless and voiced initial consonants followed by nasal vowels are represented by 8 words, i.e. 4 words contain voiceless initial consonants and 4 words voiced initial consonants. In the case of voiceless consonant onset, the glottal stop /ʔ/ has been regarded as a voiceless stop like /p/, /t/, /c/, /k/. This is due to /ʔ/ being classified as the same phonation type as the remaining sounds, voiceless, in that there is no vibration of the vocal folds (Ladefoged 1999: 609). Almost all of the vowels in the wordlist were low vowels to diminish vowel height effect on the pitch. Tones on the vowels are mid tone (no tone mark) to avoid pitch perturbation. Moreover, it appears that in the wordlist not only monosyllabic words were selected but also the last syllables of disyllabic and sesquisyllabic words because the last syllables receive a prominent sound or stress as in the monosyllabic words. The wordlist is as follows:

Oral vowels

Voiceless	Voiced
kɛ 'to be'	mɛ 'birth scar'
ʔɛ 'to love'	thàʔɛ 'chilli'
ʔa 'much'	ba 'cheap'
ʔaka 'to grill'	lola 'a kind of tree'
mapha 'to rent'	ʔàɲa 'meat'
sa 'to breathe'	phaɪɲa 'skin'
ʔɔ 'to have'	ɲàsàba 'pity'
bacɔ 'wet'	kàdi 'dull'

Nasal vowels

Voiceless	Voiced
natã 'naughty'	sanã 'to forget'
miʔã 'burn'	chamã 'to think'
sathã 'angry'	lalã 'piece'
kaikã 'crooked'	khebã 'hip'

3.3 Language consultants and data collection

For the Pwo Karen of Ban Doi, twelve language consultants of both sexes, equally, who were >60 years of age, 35-45 years of age, and <20 years of age were chosen. The language consultants were asked to pronounce each word 5 times. The number of test tokens for oral vowels in each age group was 960 (4 language consultants x 3 age group x 16 words x 5 times). The overall number of test tokens for nasal vowels was 480 (4 language consultants x 3 age groups x 8 words x 5 times). Regarding the nasal vowels, the words were pronounced twice to produce an identical number with the oral vowels above. Therefore, the test tokens used were 960 for both oral vowels and nasal vowels. The recording was done with a SONY IC Recorder ICD-MS515.

3.4 Data analysis

The entire vowel (vocalic portion) of each token was measured in respect of vowel duration, vowel amplitude and fundamental frequency. In each vowel, the time was normalized at the following points: 0%, 25%, 50%, 75% and 100%, a total of 5 measurement points. The Praat program version 4.2.09 was used for the analysis. The duration of vowels was measured in milliseconds (msec) in the range of the beginning of the vowel onset (0%) to the vowel offset (100%). The

amplitude values were measured at each peak of the vowel. The fundamental frequency values were measured at 0-100 msec as it has been reported that the initial consonant voicing influences the following vowels from 0-100 msec (Hombert, Ohala, and Ewan, 1979). This range was normalized starting from the vowel onset or 0 msec to 100 msec into the following points: 0%, 50%, and 100%. Each point was averaged. Statistical analysis, Mean, Standard Deviation (SD) and *t-test* were used. Then, bar and line graphs were drawn.

4. Results

The results detail mean vowel duration, mean vowel amplitude and mean fundamental frequency values comparing the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20).

4.1 Duration

Table 12 and Figure 1 show the mean duration values of oral and nasal vowels following voiceless and voiced initial consonants in the Pwo Karen of Ban Doi. The mean duration values of both types of oral and nasal vowels following voiceless initial consonant was significantly lower ($p < .05$) than that of voiced initial consonants for the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20), except that the nasal vowels following voiceless consonants were found to be insignificantly lower than that of the voiced consonant ($p = .200$). The mean duration values of nasal vowels were found to be inconsistently higher than those of the oral vowels. The size of the differences between the mean duration of the vowel following voiceless and following voiced consonant in each

age group was not significantly different ($p > .05$).

4.2 Amplitude

Table 13 and Figure 2 show the mean amplitude values of oral and nasal vowels following voiceless and voiced initial consonants in the Pwo Karen of Ban Doi. The mean amplitude values of both oral and nasal vowels following voiceless initial consonants were insignificantly lower ($p > .05$) than those of voiced initial consonants for the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20). The mean amplitude values of nasal vowels were found to be higher than those of the oral vowels. The differences between the mean durations in each age group were not significantly different ($p > .05$). It was found that the size of differences between the mean amplitude of the vowel following voiceless and following voiced consonants in each age group was not significantly different ($p > .05$).

4.3 Fundamental frequency

Table 14 shows mean fundamental frequency values at the 3 measurement points: 0%, 50%, and 100%. Standard deviation (SD), and *t-test* result or p-values of both oral vowels and nasal vowels following voiceless initial consonants and voiced initial consonants in the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20) are also shown. In Table 14 and Figures 3-5, “pa” represents oral vowels following voiceless initial consonants, while “ba” represents oral vowels following voiced initial consonants. As for “pã”, it represents nasal vowels following voiceless initial consonants, while “bã” represents nasal vowels following voiced initial consonants.

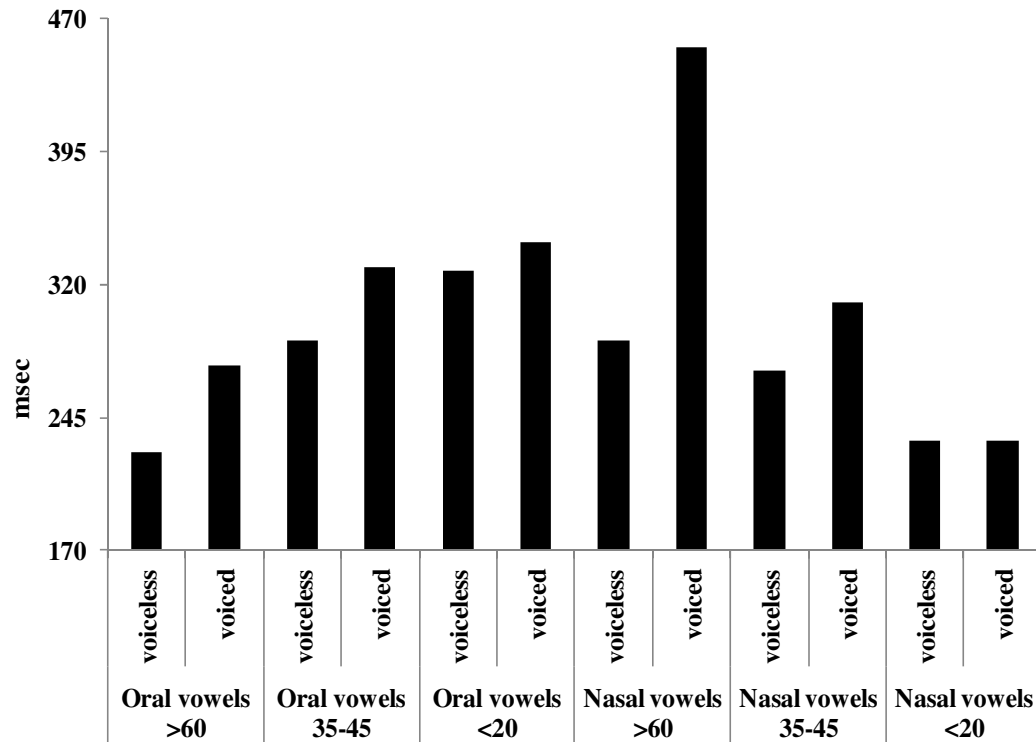


Figure 1 Mean duration values of oral vowels and nasal vowels in the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20)

Table 13 Mean amplitude values, Standard deviation (SD), and *t-test* of oral vowels and nasal vowels in the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20)

Age group	Oral vowels (dB)			Nasal vowels (dB)		
	Voiceless onset	Voiced onset	<i>t-test</i> result (p)	Voiceless onset	Voiced onset	<i>t-test</i> result (p)
>60	77.19 SD = .99	79.83 SD = 1.24	.56	78.64 SD = 1.79	79.99 SD = .90	.67
35-45	76.27 SD = .82	77.49 SD = 1.79	.62	79.86 SD = .78	80.08 SD = .97	.93
<20	80.95 SD = 1.05	81.02 SD = 1.63	.71	81.25 SD = 1.22	81.87 SD = 1.45	.89

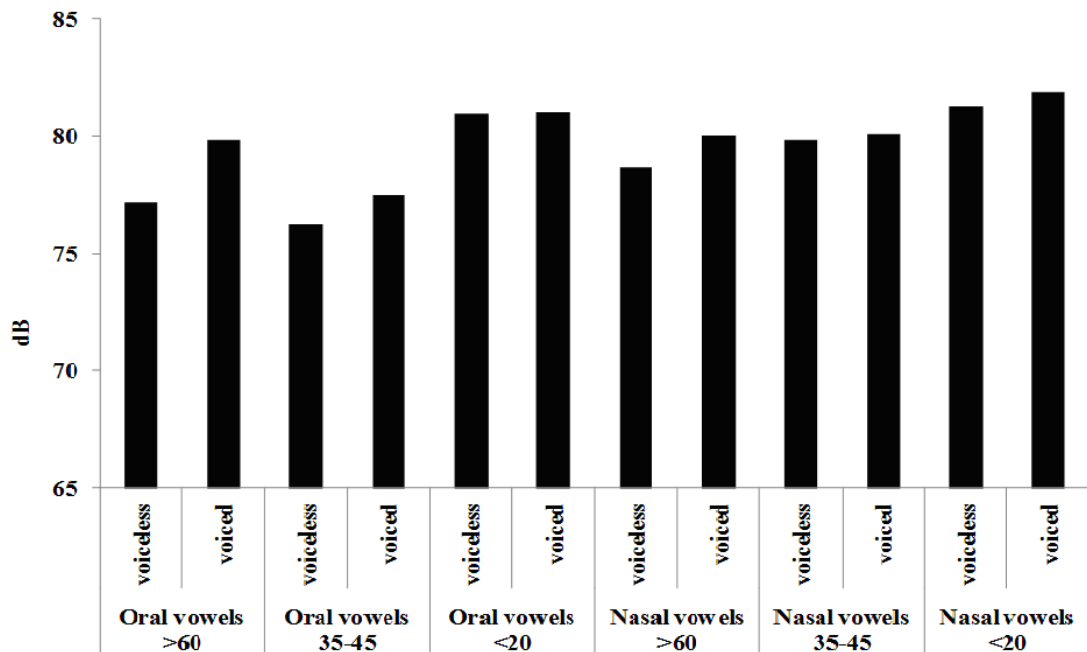


Figure 2 Mean amplitude values of oral vowels and nasal vowels in the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20)

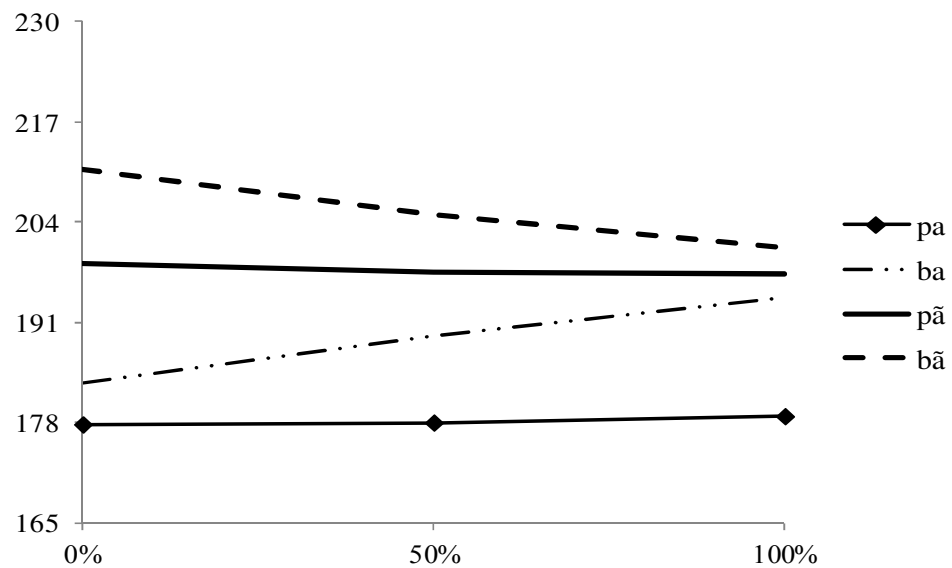


Figure 3 Mean fundamental frequency values of oral vowels and nasal vowels in the >60 years of age

Table 14 Mean fundamental frequency values, Standard deviation (SD) and *t-test* of oral vowels and nasal vowels in the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20)

	Age group								
	>60			35-45			<20		
	0%	50%	100%	0%	50%	100%	0%	50%	100%
Fundamental frequency of oral vowels following voiceless initial consonant (pa)	177.79	178.03	178.86	203.78	199.45	192.88	221.99	219.50	214.65
SD	2.44	3.12	2.89	3.05	1.26	2.75	2.47	2.50	2.36
Fundamental frequency of oral vowels following voiced initial consonant (ba)	183.09	189.21	194.22	203.92	199.33	193.67	225.88	219.12	213.35
SD	1.48	1.95	2.34	2.52	5.77	3.84	4.38	4.51	4.20
<i>t-test</i> result (p)	.089	.045	.042	.35	.39	.18	.09	.15	.22
Fundamental frequency of nasal vowels following voiceless initial consonant (pā)	198.65	197.52	197.20	213.35	211.52	209.62	222.25	218.90	215.52
SD	5.65	3.36	4.12	5.73	5.39	4.92	3.55	2.52	4.75
Fundamental frequency of nasal vowel following voiced initial consonant (bā)	210.91	204.89	200.63	205.12	200.10	197.88	224.44	220.57	213.79
SD	2.67	4.97	4.21	2.62	2.52	3.79	4.11	4.17	4.58
<i>t-test</i> result (p)	.038	.077	.095	.049	.043	.041	.093	.13	.11

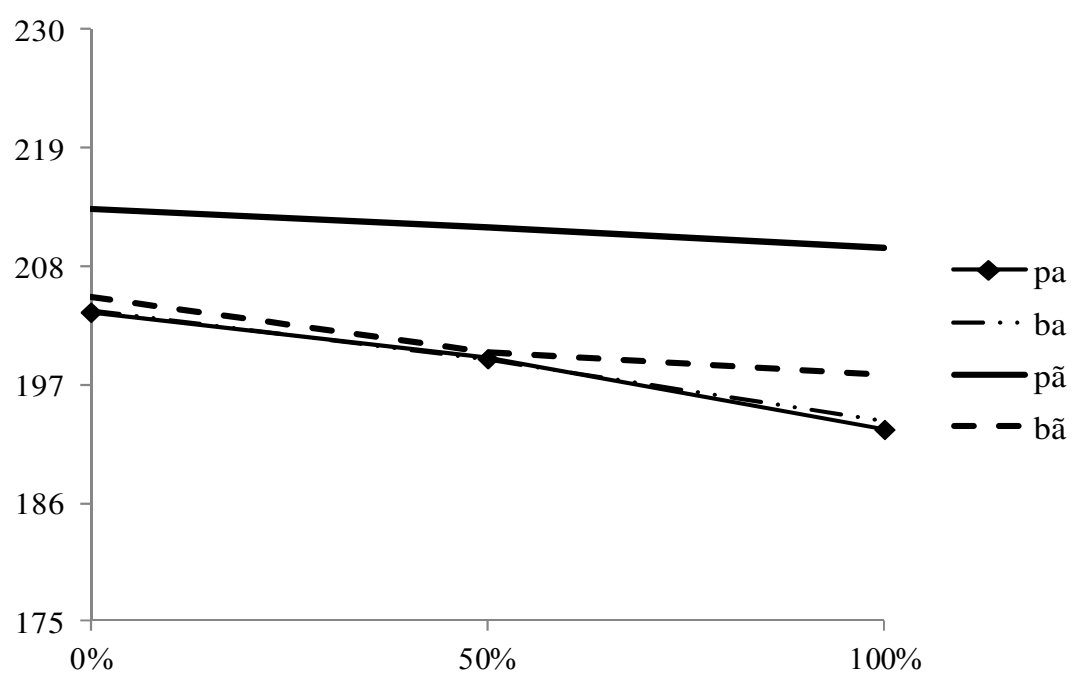


Figure 4 Mean fundamental frequency values of oral vowels and nasal vowels in the 35-45 years of age

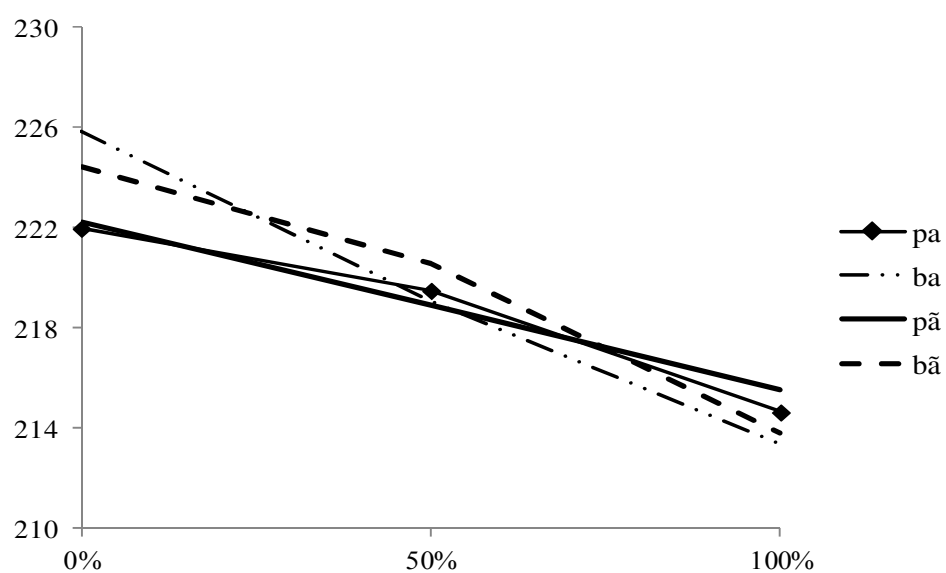


Figure 5 Mean fundamental frequency values of oral vowels and nasal vowels in the <20 years of age

From Table 14 and Figure 3, all lines were level and both oral and nasal vowels following voiced consonants were clearly higher in pitch from 0%-100%. Regarding oral vowels, the vowels following voiceless initial consonants at 0% were found to be insignificantly higher in mean fundamental frequency values compared to those following voiced initial consonants but they were significantly higher at 50% and 100%. Regarding mean fundamental frequency values, those of the nasal vowels were higher than that of the oral vowels.

From Table 14 and Figure 4 in the 35-45 age group all lines were found to be level. Oral vowels following voiced initial consonants were insignificantly higher in mean fundamental frequency values than that of the voiceless vowels, while the nasal vowels following voiced initial consonants were significantly lower in mean fundamental frequency values compared to those following voiceless initial consonants. Regarding mean fundamental frequency values, those of the nasal vowels were higher than that of the oral vowels.

From Table 14 and Figure 5 mean fundamental frequency values of clear vowels following voiced initial consonants were insignificantly higher in pitch at the onset compared to those following voiceless initial consonants. However, at the midpoint and the offset, it was found to be insignificantly lower. In the case of nasal vowels, the vowels following voiceless initial consonants were found to be insignificantly higher in mean fundamental frequency values than those following voiced initial consonants at the mid point. All lines seem to be similar in pitch contour but different in pitch height.

The size of the pitch differences seems to be larger in the >60 years of age and smaller in the 35-45 years of age, and <20 years of age, respectively. Moreover, for all vowel types, e.g. oral and nasal vowels, pitch contours were found to change from level to falling.

5. Discussion and conclusion

Linguists (Erickson 1975, Gandour 1974, Hombert et al. 1979, House and Fairbanks 1953, Lehiste 1970, Lehiste and Peterson 1961, L-Thongkum 1990, Maddieson 1984, Watkins 2002) have claimed many universal factors for the causes of tone development—initial consonant voicing, voiceless and voiced. These factors have caused the tones in all Tai languages (Li 1966), some Mon-Khmer languages such as Vietnamese and Plang (Diffloth 1980, Haudricourt 1954), Sgaw Karen and Cantonese in Sino-Tibetan (Haudricourt 1954, Li 1977, Sun 2003), and Cham in Austronesian (Thurgood 1999). However, there is one language reported not to have behaved in the same way, T'iensin, a dialect of Peking (Li 1977). Ban Doi Pwo Karen seems to be another language that presents the uncommon phenomenon of the fundamental frequency behaviour of vowels influenced by a voiced initial consonant being higher than the voiceless initial consonant. All of the three age groups displayed identical behaviour. The size of the fundamental frequency differences seems to be larger in the >60 years of age and smaller in the <20 years of age. Regarding all vowel types, e.g. oral and nasal vowels, the fundamental frequency contours were found to change in the same direction, level to falling. This means that pitch height may have been used as a cue to perceive tone differences. It can be inferred from this that voiced initial consonant tends to cause a high

tone, while voiceless initial consonants tend to cause a low tone. The phenomenon is an unusual case. However, when searching into the voice register of the vowels following some voiceless consonants, it was found that those vowels in the three age groups were pronounced with breathy voice vowels. As the voice register of vowels was found to play a major role in causing tone birth (L-Thongkum 1989, 1990, Thurgood 2007), so breathy vowels have prominently affected the mean fundamental frequency values causing low pitch in vowels following voiceless consonants.

Therefore, as well as the process of stiffening (for voiceless) and slackening (for voiced) the cricothyroid muscles, there might be low muscular tension with weak medial compression and medium longitudinal tension of the vocal folds causing the vibrations' frequency to be just below the value typical of the modal voice (Eckert and Laver 1994).

The mean amplitude of both types of vowel (oral vowel and nasal vowel) following voiceless initial consonants is lower than that of voiced initial consonants for the over-sixty group (>60), the middle group (35-45), and the under-twenty group (<20). The amplitude of the nasal vowel was found to be higher than that of the oral vowel. This is in line with previous research (Amelot and Rossatto 2007, Ladefoged 2003, Picket 1998, Whalen and Beddor 1989). However, the duration of the nasal vowel was found to be inconsistently higher than that of the oral vowel. This does not correspond with other research in which the duration of the oral vowels was found to be less than that of the nasal vowels (Amelot and Rossatto 2007, Ladefoged 2003, Picket 1998, Whalen and Beddor 1989).

In conclusion, the initial consonant voicing perturbation of the fundamental frequency of oral vowels and nasal vowels was in the same direction, that is, a voiceless initial consonant causing a lowering of mean fundamental frequency and a voiced initial consonant causing an increase in of mean fundamental frequency in Pwo Karen of Ban Doi. This challenges the tonogenesis universality claimed in previous research. The three age groups were reliable in showing a tone development tendency. However, physiological analysis should be initiated for further explanation.

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