The Interaction between Intrinsic Pitch and Some Social Factors in Mon-Khmer Languages

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งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาความสัมพันธ์ระหว่างระดับเสียงธรรมชาติของสระกับปัจจัยทางสังคม อันได้แก่ เพศและอายุ ในภาษาตระกูลมอญ-เขมรจำนวน 3 ภาษา ประกอบด้วย ภาษาชอง ภาษาขมุ และภาษาญัฮกุร ในการวิเคราะห์ระดับเสียงธรรมชาติของสระ ผู้วิจัยใช้โปรแกรม Praat ในการวัดค่าระยะเวลาและค่าเซมิโทน สระสูงที่ใช้ศึกษาได้แก่สระ [i] และ [u] ส่วนสระต่ำได้แก่สระ [a] ผู้บอกภาษาในแต่ละภาษามีจำนวน 12 คน แบ่งออกเป็น 3 กลุ่มอายุ กลุ่มอายุละ 4 คน กลุ่มอายุที่หนึ่งอายุตั้งแต่ 60 ปีขึ้นไป กลุ่มอายุที่สองอายุ 35-45 ปี และ กลุ่มอายุที่สามอายุไม่เกิน 20 ปี แต่ละกลุ่มอายุประกอบด้วยเพศชาย 2 คน และเพศหญิง 2 คน ผลการวิจัยพบว่าระดับเสียงธรรมชาติของสระปรากฏในภาษาขมุและภาษาญัฮกุร แต่ไม่ปรากฏในภาษาชอง ปัจจัยทางสังคม คือ เพศและอายุ มีอิทธิพลต่อค่าของระดับเสียงธรรมชาติของสระในทุกภาษา ผลการวิจัยสนับสนุนแนวคิดที่ว่าระดับเสียงธรรมชาติของสระเกิดจากการเคลื่อนไหวของสรีระที่ใช้ออกเสียงตามธรรมชาติ

Abstract

The objective of this research was to investigate the interaction between intrinsic pitch and some social factors, namely sex and age, in 3 Mon-Khmer languages: Chong, Khmu' and Nyah Kur. High vowels, [i] and [u], and the low vowel [a] were investigated; vowel duration and semitones were measured using Praat. For each language, the informants were 2 males and 2 females: one each over the ages of 60, 35 and 45 years old, and one under 20 years old. The IF0 is present in Khmu' and Nyah Kur, but absent in Chong. Age and sex are significant factors affecting the size of the IF0 across languages. As a result, the research supports the automatic consequence theory of the IF0 phenomenon.

1. Introduction

The interaction between vowel height and fundamental frequency is well-documented. For example, the high vowels [i] and [u] have a higher relative pitch than does the lower vowel [a]. This phenomenon is called intrinsic pitch (IF0).

Based on various published sources on 31 languages, Whalen and Levitt (1995) examined a universal interaction between vowel height and fundamental frequency (F0), or the IF0. The results mainly support the automatic consequence theory as opposed to the enhancement theory (Diehl, 1991; Diehl and Kingston, 1991; Pape and Mooshammer, 2006), which argues for the deliberate control of the IF0 executed by the speaker to make the vowels more salient to the listener. The automatic consequence theory suggests that the IF0 is intrinsic; it is a result of successful vowel production and due to physiological mechanisms (Honda and Fujimura, 1991; Whalen et al., 1998) such as cricothyroid activity, which tenses vocal folds to cause higher pitch, and slackens them to cause lower pitch (Honda and Fujimura, 1991; Hoole et al., 2004; Whalen et al., 1998). In contrast, the enhancement theory suggests the IF0 as a perceptual cue of different vowel spaces. The IF0 size is changeable across languages to signal differences in vowel inventories. For example, a 3-vowel-inventory language shows the IF0 with a smaller size than that of a 12-vowel-inventory language (Verhoeven and Van Hoof, 2007). In sum, the consistency of the IF0 across languages can signal an automatic consequence; however, if there are the IF0 differences among languages, this signals a deliberate consequence—that the IF0 is a variable that languages choose to enhance. Whalen and Levitt (1995) found the presence of the IF0 across the world's languages.

Though the IF0 is claimed to be universal, there are some factors that constrain the size of the IF0. Whalen and Levitt (1995) investigated factors affecting the size of the IF0, e.g., front and back of the tongue, sex, the size of the vowel inventory, etc. As a function of these factors, the intrinsic pitch is always present. Up to now, linguists have found some factors that affect differences in the IF0 to be universal, while some are controversial, and still others require more information before they can be verified and explained.

First, with respect to "frontness and backness", it is important to note that this is found not to be a significant factor in terms of the causality of the IF0 differences (Whalen and Levitt, 1995; Verhoeven and Van Hoof, 2007). However, it is plausible that a back vowel [u]

might have a higher F0 than a front vowel [i] due to the active lowering of the larynx in [u] (Petersen, 1978). Second, the effect of the size of the vowel inventory on the IF0 size seems to be controversial (Whalen and Levitt, 1995; Verhoeven and Van Hoof, 2007). On the one hand, the size of the vowel inventory did not affect the IF0. Such a result suggested the IF0 as truly intrinsic and not a deliberate enhancement of speech signals (Whalen and Levitt, 1995). On the other hand, the size of the vowel inventory affected the differences between the IF0s, which suggested that the IF0 was apparently related to the deliberate enhancement of vowel qualities (Verhoeven and Van Hoof, 2007). Third, the size of tone inventories in the languages of Africa shows no direct correlation between tone numbers and the size of the IF0. A correlation was also found between tone space and the absence of the IF0 in Mambila. Connell (2002)'s findings support the consistency of the IF0 across tone languages, and thus the automatic consequence theory. Fourth, the factor of sex remains in need of further investigation. According to the survey of Whalen and Levitt (1995), some previous research under investigation has not separated out the informants involved by sex; this factor, therefore, requires considerably more evidence before any reliable conclusions can be reached. The other factor believed to have an effect on the differences between the IF0s in the previous research is age. Infants were found to show the IF0, although they do not have vowel inventories to enhance (Whalen et al., 1995). The developmental stage of puberty in the male is also suggested to be a factor in such a difference, but no explanation is immediately obvious (Whalen and Levitt, 1995: 357).

Age and sex were reported to have an effect on vocal tract configurations (Iseli et al., 2007; Ménard et al., 2007). Ménard et al. (2007) reported, with respect to the vocal tract length, that a newborn's tract is 7.1 cm long, and that a 4-year-old's is 10.5 cm long. For males and females, the vocal tract lengths for adults are 16 cm and 14.3 cm, respectively. Moreover, some acoustic cues are found to be sex- and age-dependent. The IF0 is higher in the female than in the male (Fant, 1960; Laver and Trudgill, 1991) and higher in children than in adults (Lee et al., 1999; Nishio and Niimi, 2008).

This paper has 2 aims. The first aim is to investigate sex and age, and more specifically to consider whether they are factors that constrain the IF0. If differences in the IF0 occur in different age groups and with different sexes of informants, the automatic consequence theory is likely to be accepted. Three Mon-Khmer languages—Chong, Khmu',

and Nyah Kur, which show a small difference in their numbers of vowel inventories, with a total of 18-20 monophthongs—were selected. Each language study is built on 3 age groups of informants: a group of those over-sixty, a middle-aged group (35-45 years of age), and an under-twenty age group. Each age group was comprised of 2 females and 2 males. The second aim was to investigate the IF0 phenomena in high and low vowel counterparts; the high vowels [i] and [u] opposed to the low vowel [a] were selected for study due to the fact that most previous studies have considered the IF0 phenomenon with respect to [i], [u] vs. [a], and also because these vowels are present in most of the world's languages (Maddieson, 1984).

2. Preliminary background

In this section, the concept of intrinsic pitch, the factors affecting differences in the IF0, and their implications for automatic consequence theory and enhancement theory are introduced.

2.1 Intrinsic pitch

Intrinsic pitch (IF0) first began to be recognized in 1896-1897 in German (Meyer 1896-7, cited in Whalen and Levitt, 1995). It was suggested that in the German language, the IF0 of high vowels tended to be a higher fundamental frequency than for low vowels, and that these apparently relate to higher and lower auditory pitch, respectively. Since then, a number of studies of this phenomenon have been conducted. Whalen and Levitt (1995) synthesized previous research done with 31 languages from all major language families to confirm the existence of intrinsic pitch. It was concluded that intrinsic pitch is a universal phenomena. In other words, high vowels such as [i], in which the tongue height position is higher, tend to be higher in pitch than low vowels like [a], in which the tongue height position is lower.

2.2 Factors affecting differences in the IF0

Linguistic studies have long been concerned with factors affecting the size of the IF0. Those factors consist of (1) frontness and backness, (2) the size of vowel inventories, (3) types of language, (4) sex, and (5) age. Sex and age also function as social factors.

2.2.1 The front-back dimension

With respect to frontness and backness, the analysis of Whalen and Levitt (1995) found that this is not a significant factor in the determination of the IF0 differences. The mean

difference between the IF0 values for front vowels [i] and those for back vowels [u] was 2.5 in Hz or 0.24 in semitone across all 31 languages. The same result was found in Moroccan Standard Arabic and Belgian Standard Dutch (Verhoeven and Van Hoof, 2007). Eleven speakers of Moroccan Standard Arabic used in the study were divided by sex into 2 groups with 6 males and 5 females, respectively, while 10 speakers of Belgian Standard Dutch were divided into 5 males and 5 females. All were 22 years of age. The effect of the front-back dimension on the IF0 of vowels in these 2 languages was found to be insignificant.

2.2.2 The size of vowel inventories

The effect of the vowel inventory's size on the IF0 size is controversial. While the size of the vowel inventory did not affect the IF0 in the 31 languages analyzed by Whalen and Levitt (1995), opposite results were found in Moroccan Standard Arabic and Belgian Standard Dutch (Verhoeven and Van Hoof, 2007). It has been reported that Standard Arabic has 3 monophthongs, while Standard Dutch has 12 monophthongs. The effect of the IF0 in Standard Arabic was 1.28 semitones, and in Standard Dutch it was 2.78 semitones. Comparing the IF0 values of the 2 languages, researchers claimed that the effect of vowel inventory on the IF0 values was significantly different.

2.2.3 Type of language

According to L-Thongkum (1988) and Yip (2002), languages are classified into at least 3 types: 1) tonal languages, e.g., Thai, Chinese; 2) register languages, e.g., Wa, Chong; and 3) non-tonal and non-register languages, e.g., English. It has been reported that types of language do not affect the IF0 difference (Whalen and Levitt, 1995; Teeranon, 2007). Connell (2002) showed similar results with 4 African languages from the tonal language category. In addition, the tone inventory did not affect the IF0. Although the IF0 has been found to exist in tonal languages, there is some limitation in Mambila, which showed an absence of the IF0. However, Connell (2002) argued that the absence of the IF0 in Mambila does not support the enhancement theory, as this absence is phonologically explainable: one might say, for example, that level tone combines into contour tones, which some of these contour tones involve adjacent tones result in small modulations in F0 (Connell, 2002: 119) and an absence of the IF0 in Mambila.

2.2.4 Sex

According to the survey of Whalen and Levitt (1995), previous research showed the IF0 effects of 13.9 Hz for males and 15.4 Hz for females. This magnitude showed a significant gender difference, with females experiencing a bigger effect than males. However, when one considers the IF0 effects in semitones, males experience a bigger effect than females. However, as previous research hasn't separated out its informants based on their sex, this factor requires considerably more evidence before its results can be considered conclusive (Whalen and Levitt, 1995). Recently, Verhoeven and Van Hoof (2007) found Moroccan Standard Arabic and Belgian Standard Dutch IF0 values unaffected by sex. In their study, the IF0 for females was 2.02 semitones, with a value of 2.04 semitones for males.

2.2.5 Age

This factor has not been stated clearly in previous studies. Whalen et al. (1995) showed the effect of the IF0 in 6 month-old babbling babies. The data on some languages studied in 5 to 11-year-old informants showed similar results (Peterson and Barney, 1952; Peterson, 1961). It is also questionable whether the developmental stage of puberty in the male is a contributing factor in the IF0 difference, as might be true due to the lowering of the larynx (Whalen and Levitt, 1995: 357).

2.2.6 Implications of automatic consequence theory and enhancement theory

The aims of studying the IF0 are twofold: first, to test for universality, and secondly, to test whether the IF0 values are affected by linguistic factors, which apparently relate to automatic consequence theory and enhancement theory. If factors such as front and back dimension, the size of vowel inventories, tonal languages, etc. do not limit the intrinsic pitch phenomenon, it is claimed that the IF0 is an automatic consequence of vowel articulation (Whalen and Levitt, 1995; Connell, 2002). Conversely, the enhancement theory (Diehl, 1991; Di Benenetto, 1994; Gussenhoven, 2004) emphasizes the deliberate control of speakers in producing the intrinsic pitch difference by using the cricothyroid muscle and, thus, make the vowel quality salient to hearers. If human languages use the IF0 to control vowel qualities, the IF0 should exist in every language, and the presence of the IF0 might be affected by the factors stated above.

3. Methodology

3.1 Language data

The phonologies of the 3 Mom-Khmer languages are as follows:

Chong

The Khlong Phlu dialect of Chong is spoken in the Khao Khitchakut district of Chanthaburi Province. The language is comprised of 21 consonant phonemes /p, ph, b, t, th, d, c, ch, k, kh, ʔ, m, n, ɲ, ŋ, s, h, r, l, w, j/, 18 monophthongs /i, ii, ɨ, ɨɨ, u, uu, e, ee, ə, əə, o, oo, ɛ, ɛɛ, a, aa, ɔ, ɔɔ/, and 1 diphthong /uə/. There are 4 registers: clear voice /R1/, clear voice followed by glottal constriction /R2/, breathy voice /R3/, and breathy voice followed by glottal constriction /R4/ (L-Thongkum, 1991). All wordlists of Chong used in this study are clear voice.

Chong is developing 4 tones; as L-Thongkum (1991: 141) states, "In fact, some dialects of Chong, such as the one spoken in Chamkhlo' Village, Takhianthong Sub-district, Makham District, have already become tonal: presyllables are dropped; phonation types are less prominent and in some cases disappear; and pitch differences can be heard clearly, especially in slow speech. Our Chong informants also describe their language as having high, higher, mid and low tones"

Khmu'

Khmu' is spoken in Huay Sataeng, Thung Chang district of Nan province. The language is comprised of 22 consonant phonemes /p, ph, b, t, th, d, c, ch, k, kh, ʔ, m, n, ɲ, ŋ, f, s, h, r, l, w, j/, 20 monophthongs /i, ii, ɨ, ɨɨ, u, uu, e, ee, ə, əə, o, oo, ɛ, ɛɛ, ʌ, ʌʌ, a, aa, ɔ, ɔɔ/, and 3 diphthongs /iə, uə, ɨə /. There are 2 registers: clear voice /R1/ and breathy voice /R2/ (L-Thongkum et al., 2008). All wordlists for Khmu' used in this study are clear voice.

Some Khmu dialects retain their voicing distinction with regard to the initial consonants, whereas some Khmu dialects show the register distinction of the vowels. However, the loss of these 2 registers in some dialects is now substituted by low tones (Premsrirat, 2003).

Nyah kur

Nyah kur is spoken in Ban Rai, a village in the Thepsathit district of Chaiyaphoom province. The language is comprised of 21 consonant phonemes /p, ph, b, t, th, d, c, ch, k, kh, ʔ, m, n, ɲ, ŋ, ɟ, h, r, l, w, j /, 18 monophthongs /i, ii, ɨ, ɨɨ, u, uu, e, ee, ə, əə, o, oo, ɛ, ɛɛ, a, aa, ɔ, ɔɔ/, and 3 diphthongs /iə, uə, ɨə / (L-Thongkum, 1988). Nyah Kur is also comprised of 2 registers, clear voice and breathy voice (L-Thongkum, 1984).

As with Chong, Nyah Kur is predicted to develop 2 tones from types of vowels in terms of phonation (L-Thongkum, 1984, 1988). The high tone is associated with clear voice, while the low tone is associated with breathy voice.

3.2 Wordlists

A number of words were selected, mainly from field work, related dictionaries, research reports, and other related documents. Before the data were recorded, every word in the list was carefully checked with an informant of each language. Five test tokens were selected for 3 pairs of high and low vowels contrasts: [i]-[ɛ], [ɨ]-[a], and [u]-[ɔ]. To avoid pitch perturbation from voicing consonants, 5 minimal pairs surrounded by voiceless plosive consonants were prepared, e.g., [pit] vs. [pɛt], [tuk] vs. [tɔk]. The informants were asked to pronounce them 5 times. However, the first 3 times were selected, in order to avoid the intonation effect. In the event of lacking minimal pairs, nonsense words were set to complete the wordlists (See details in Appendix A).

3.3 Informants

In each language, 12 native informants of both sexes were selected, 6 males and 6 females, aged 20-60. The informants were divided into 3 groups; the under-twenty group (lower than 20 years of age), the middle group (35-45 years of age), and the over-sixty group (more than 60 years of age). Each group was composed of 4 informants, 2 male and 2 female. The number of tokens was 2,700 (12 informants x 3 vowels x 5 words x 5 times x 3 languages). The recording was done with a SONY IC Recorder ICD-MS515.

3.4 Acoustic parameters and the method of measurement

The whole vowel was measured with respect to duration and fundamental frequency. In each vowel, time was normalized at the middle point: 50%. The Praat program version 4.2.09 was used for the analysis. Microsoft Excel was used for analyzing the means of

duration and fundamental frequency. The fundamental frequency values were later converted to semitones. The mean values of the duration and semitones were also analyzed statistically using a t-test and ANOVA with a 95% level of confidence. Tables and line graphs were drawn.

4. Results

The mean duration of each pair of high and low vowels is presented; then the IF0 is presented for Chong, Khmu', and Nyah Kur.

4.1 Duration

The mean duration of high and its low counterparts were measured due to its having been reported that duration has affected the F0 or the semitones of the vowels (Svantesson, 1991; L-Thongkum et al., 2007).

Tables 1 through 3 present the duration of high vowels and their low counterparts; [i], [u] vs. [a]. In most cases of Chong (see Table 1), low vowels show significantly longer duration than high vowels, with the exception of the results for males in the middle age group, where the difference was found to be insignificant. In some cases of Khmu' (See Table 2.), low vowels show significantly longer durations than high vowels. Some cases show the low vowels as being of insignificantly shorter duration than the high vowels. In most cases of Nyah Kur (See Table 3.), low vowels are of significantly longer duration than high vowels, with the exception of the results for females in the middle age group, where low vowels are insignificantly shorter than high vowels.

In sum, the results show the consistency of low vowels as opposed to high vowels with respect to increased lengths of duration in Chong and Nyah Kur, but we also find that in Khmu', this phenomenon is not consistent.

Table 1 Mean duration, mean differences between high and low vowels; [i], [u] vs. [a], and the significant test in Chong

		i	u	a	Mean diff. (i, u vs. a)	Sig.
The over sixty	Female	111.1	124.3	158.0	40.3	0.00
	Male	123.9	119.9	143.3	21.4	0.00
The middle-aged	Female	111.3	105.2	125.7	17.5	0.01
	Male	118.6	104.7	120.6	8.9	0.83
The under twenty	Female	168.4	124.8	166.7	20.1	0.00
	Male	158.7	115.2	157.4	20.5	0.00

Table 2 Mean duration, mean differences between high and low vowels; [i], [u] vs. [a], and the significant test in Khmu'

		i	u	a	Mean diff. (i, u vs. a)	Sig.
The over sixty	Female	93.9	86.4	84.7	-5.5	0.10
	Male	112.0	105.3	106.5	-2.2	0.19
The middle-aged	Female	128.7	145.8	138.9	1.7	0.31
	Male	88.4	99.5	112.2	18.3	0.02
The under twenty	Female	112.4	126.4	150.9	31.5	0.00
	Male	101.8	125.5	109.6	-4.1	0.37

Table 3 Mean duration, mean differences between high and low vowels; [i], [u] vs. [a], and the significant test in Nyah Kur

		i	u	a	Mean diff. (i, u vs. a)	Sig.
The over sixty	Female	173.9	157.5	190.9	25.2	0.00
	Male	138.4	128.6	154.7	21.2	0.00
The middle-aged	Female	128.8	133.1	119.8	-11.2	0.30
	Male	102.3	109.7	96.6	-9.4	0.20
The under twenty	Female	154.4	176.2	289.4	124.1	0.00
	Male	127.3	139.7	185.0	51.5	0.00

4.2 The effect of sex and age on the IF0

4.2.1 Chong

Table 4 and Figure 1 show the IF0 in Chong with respect to social factors, sex and age. The overall IF0 values were found to exist in both sexes and the 3 age groups. However, it was found that high and low vowels in female speakers aged sixty years old or older and male speakers aged 35-45 years old showed no the IF0. The high vowels show lower semitones than do the low vowels, or show no IF0; the IF0 values in the table are negative.

4.2.1.1 sex

In Table 4, it is shown that in the over-sixty group and the middle-aged group, sex bears no significant relation to the IF0; this is due to the absence of the IF0 in female speakers over the age of 60, and in males between the ages of 35 and 45 years old. On the contrary, in the under-twenty age group, sex has a significant effect on the IF0. When comparing the IF0 size between females and males in the under-twenty group, females show significantly higher IF0 than do males.

4.2.1.2 age

Speakers aged less than 20 years old show the most consistency in terms of the IF0 phenomena. The over-sixty and the middle-aged groups show the absence of the IF0, especially in female and male speakers respectively. It was found that age was not a significant factor affecting the IF0 for high vowels and low vowels in Chong ($F(2, 198)=1.02$, $p=0.37$). The largest IF0 size is found in the under-twenty group, where the average for both sexes is 1.6 ST.

Table 4 Semitones and the IF0 (ST) in Chong

		High vowel		Low vowel	IF0	Sig.
		i	u	a		
The over-sixty	Female	11.6	9.1	11.8	-1.5	0.22
	Male	7.8	7.3	7.1	0.5	
The middle-aged	Female	10.7	8.7	7.6	2.1	0.20
	Male	9.7	7.6	10.2	-1.6	
The under-twenty	Female	12.4	14.5	11.6	1.9	0.01
	Male	11.2	11.2	9.9	1.3	

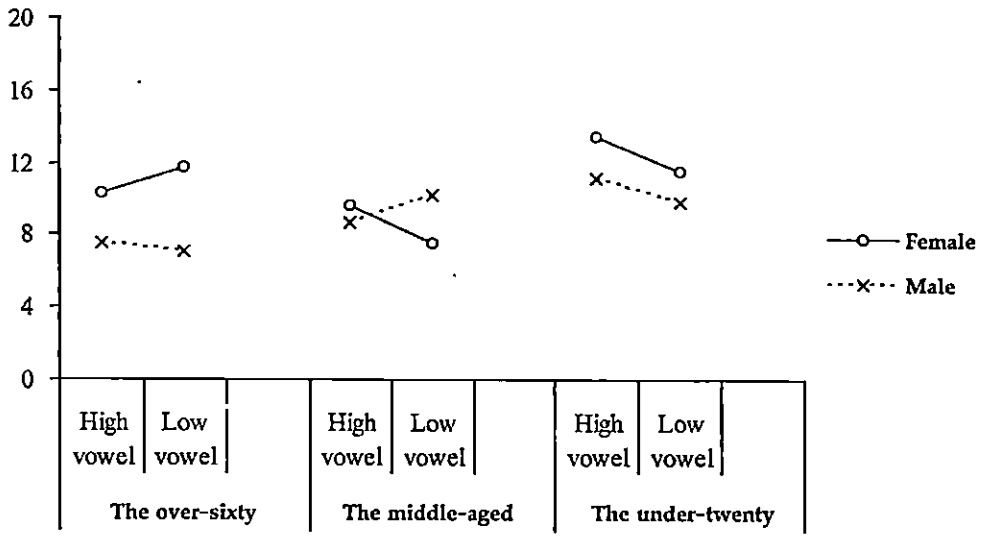

Figure 1 The IF0 (ST) of different age and sex in Chong

4.2.2 Khmu'

Table 5 and Figure 2 show the IF0 in Khmu' with respect to social factors, sex and age. Compared to the IF0 values found in Chong, the IF0 is present in both sexes in the 3 age groups for Khmu'.

4.2.2.1 sex

The results show consistency for the IF0 phenomenon in both sexes of Khmu' speakers. The IF0 for males is always significantly higher than for females (See Table 5 and Figure 2).

4.2.2.2 age

Speakers from the 3 age groups show the IF0 phenomena. Unlike in the case of Chong, it was found that age was a significant factor affecting the IF0 for high vowels and low vowels in Khmu' ($F(2, 198)=22.78$, $p=0.00$). The largest IF0 size was found in the over-sixty, where the average size of the IF0 for both sexes is 5.4 ST.

Table 5 Semitones and the IF0 (ST) in Khmu'

		High vowel		Low vowel	IF0	Sig.
		i	u	a		
The over-sixty	Female	12.0	12.7	8.8	3.6	0.00
	Male	11.2	12.3	4.6	7.2	
The middle-aged	Female	13.2	13.6	11.3	2.1	0.00
	Male	4.6	5.3	1.1	3.9	
The under-twenty	Female	15.1	15.2	11.5	3.7	0.00
	Male	8.3	9.5	4.6	4.3	

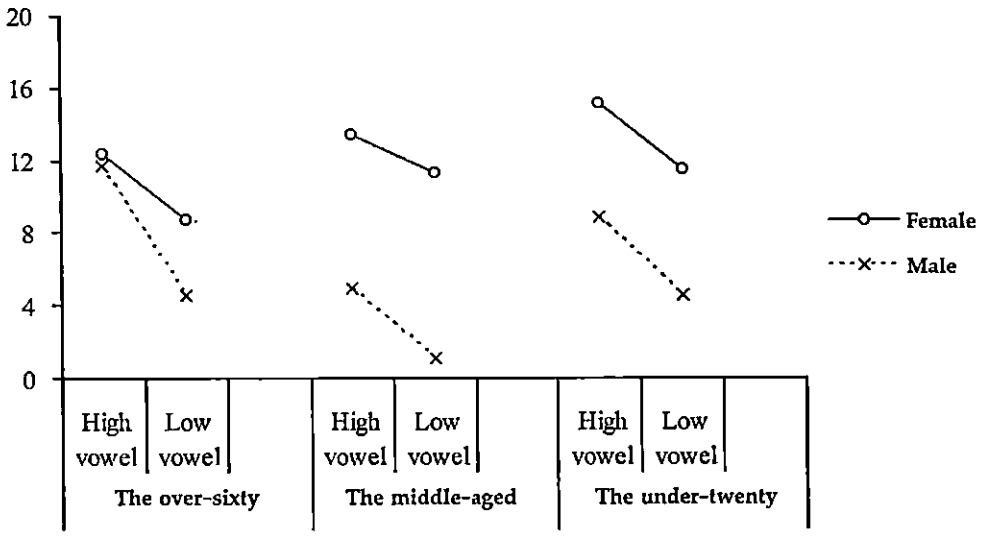

Figure 2 The IF0 (ST) of different age and sex in Khmu'

4.2.3 Nyah Kur

Table 6 and Figure 3 show the IF0 in Nyah Kur with respect to social factors, sex and age. In Nyah Kur, the IF0 were found in both sexes of the 3 age groups.

4.2.3.1 sex

As is the case with Khmu', the results show consistency in the IF0 phenomenon in both sexes of Nyah Kur speakers. The IF0 for males is significantly higher than that for females (See Table 5 and Figure 2). However, it was found that the size of the IF0 in females and males was similar.

4.2.3.2 age

Speakers of the 3 age groups show the IF0 phenomena like Khmu'; it was found that age was a significant factor affecting the IF0 for high vowels and low vowels in

Nyah Kur (F(2, 198)=3.16, p=0.00). The largest IF0 size was found in the middle-aged group, where the average IF0 for both sexes is 2.6 ST.

Table 6 Semitones and the IF0 (ST) in Nyah Kur

		High vowel		Low vowel	IF0	Sig.
		i	u	a		
The over-sixty	Female	8.4	11.3	8.1	1.8	0.00
	Male	3.9	5.2	1.9	2.7	
The middle-aged	Female	13.1	14.1	11.0	2.6	0.00
	Male	6.3	5.7	3.4	2.6	
The under-twenty	Female	13.5	14.5	12.2	1.8	0.00
	Male	12.7	13.0	9.9	3.0	

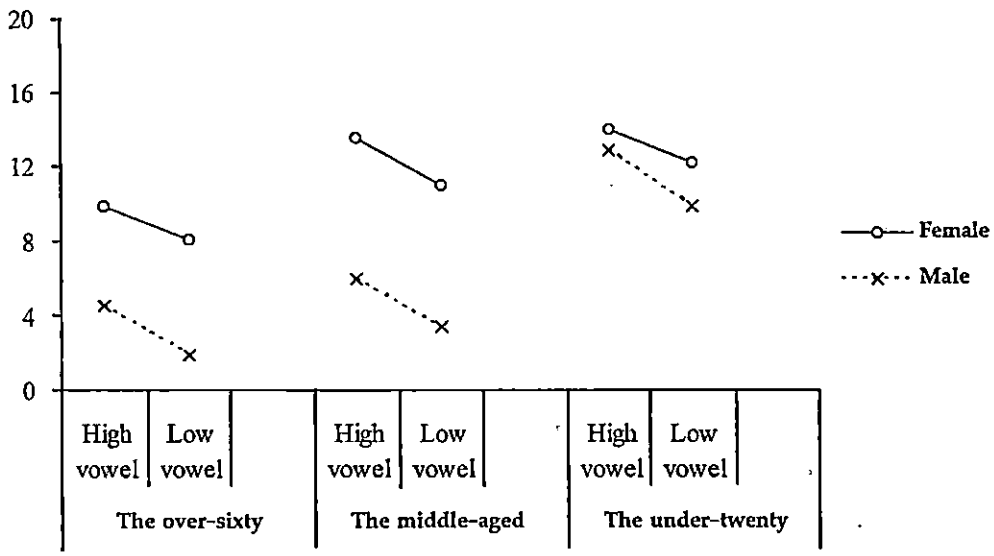

Figure 3 The IF0 (ST) of different age and sex in Nyah Kur

5. Discussion

This paper examined whether 2 social factors, sex and age, affect the differences in the IF0 for Chong, Khmu', and Nyah Kur. These 3 languages are of the same language family, and they contain similar numbers of monophthongs: 18 in Chong and Nyah Kur, and 20 in Khmu'. The informants are 2 females and 2 males from the 3 age groups: the over-sixty, middle-aged, and under-twenty. The pairs of high and low vowel counterparts are [i], [u] and [a].

It has been revealed that the IF0 exhibits consistency in Khmu' and Nyah Kur, but not in Chong (See Table 4 and Figure 1). The IF0 in the over-sixty and the middle-aged groups in

Chong are apparently restricted. Based on this acoustic study, it was indicated that the IF0 may not be a universal phenomenon; it is perhaps rather a language-specific phenomenon, which supports the findings found in the Romance languages (Pape and Mooshammer, 2008). But the present results would argue for the IF0 as a phonetic universal. It is tempting to suggest that the absence of the IF0 in Chong is due to the suprasegmental system of Chong's changing, making it go from a toneless to a tonal language. And it was found that Chong is developing 4 level tones as it loses phonation types of vowels (L-Thongkum, 1991), while the other 2 languages are developing only 2 level tones. Therefore, the IF0 values in Chong are suspected to develop 4 tones contrast, which is crowed in tone space comparing to the 2 languages. The findings regarding the IF0 in Chong seem to be congruent with the absence of the IF0 in Mambila (Connell, 2002), which is restricted by crowed F0 space in its tonal system.

The effect of sex on the IF0 differences was not significant in the over-sixty and the middle-aged groups in Chong due to the absence of the IF0, but it was significant in the under-twenty group. It appears that the size of the IF0 in females is significantly larger than in males. In Khmu' and Chong, sex is found to have a significant effect. In the 2 languages, the size of the IF0 is significantly larger in males than in females. The findings seem to correspond with what was found in Whalen and Levitt (1995), which found males to have larger IF0s than females did. On the contrary, Standard Arabic and Standard Dutch (Verhoeven and Van Hoof, 2007) show that sex is not correlated significantly with the IF0. From the acoustic data, this study shows that the correlations between the IF0 size and sex vary across languages. Though there is no obvious physiological explanation for this, it is suggested that females tends to have less harsh voices, while man tends to have more harsh voices (Chasaide and Gobl, 1999: 458), and that this might seemingly be correlated with the raising and lowering of the larynx, respectively, and the IF0 differences that were substantial in Khmu' and Nyah Kur.

Age was found to be a significant factor in the difference in the IF0 size among the 3 languages. The differences in the size of the IF0s in each age group in the 3 languages are varied. In Chong, the IF0 size in the under-twenty group is the largest, while in Khmu' and Nyah Kur, the largest IF0 is in the over-sixty and middle-aged groups, respectively. One explanation for this effect is the mode of phonation in terms of age—the lowering of larynx in

the old and in the male during puberty—as a factor causing the IF0 differences (Rose, 1989; Whalen and Levitt, 1995).

Another explanation for the effects of age and sex on the size of the IF0 are vocal tract configurations (Iseli et al., 2007; Ménard et al., 2007). Ménard et al. (2007) report that the vocal tract is longer in children than it is in adults, and longer in males than in females (16 cm vs. 14.3 cm); thus, F0 would be higher in females than in males (Fant, 1960; Laver and Trudgill, 1991), while F0 would be higher in children than in adults (Lee et al., 1999; Nishio and Niimi, 2008). That is, the longer the vocal tract, the lower the larynx, which causes lower F0. Correspondingly, a lower F0 means a smaller-sized IF0.

The results show that the intrinsic vowel duration is a phonetic tendency not yet established as universal. The intrinsic length of vowels is not as universal as intrinsic pitch. It is a specific characteristic that differs from language to language. It is also reported not to appear in Farsi, Norwegian (Cochrane, 1970), Herve French (Detry, 1985), and Waic languages (Teeranon, 2007).

The presence of the IF0 in different sexes and age groups in the Khmu' and Nyah Kur shows the IF0 to be truly intrinsic. The IF0 neither enhances vowel differences nor is under the deliberate control of speakers; it is rather the physiological settings that lead to successful vowel articulation. The findings are congruent with the automatic consequence theory.

6. Conclusion

The IF0 phenomenon is present in Khmu' and Nyah Kur, but it is absent in Chong. As the absence of the IF0 in Chong is explained through its changes from phonation types to tones, this study concludes that the IF0 is a universal phenomenon. Sex and age are factors that significantly affect the IF0 size. It supports the automatic consequence theory of vowel production due to the presence of the IF0 differences.

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Appendix A

Chong wordlists

i	u	a
pic 'to sleep'	puk 'rotten'	pat 'to abandon'
tit 'to be in debt'	tuk 'non-sense word'	tak 'thumb'
cit 'non-sense word'	cuk 'non-sense word'	cak 'to shot'
kic 'small'	kup 'to turn up side down'	kat 'to cut down trees'
ʔic 'excrement'	ʔut 'non-sense word'	ʔap 'non-sense word'

Khmu' wordlists

i	u	a
pic 'to discard'	put 'to stop the fire'	pak 'to break'
tit 'to rut'	tuk 'to tie'	tak 'to stick'
cit 'to graze'	cuk 'rat'	cap 'to hold'
kit 'non-sense word'	kut 'non-sense word'	kat 'cold'
ʔic 'excrement'	ʔut 'hot'	ʔap 'non-sense word'

Nyah Kur wordlists

i	u	a
kəpic 'to crush (with finger)'	puk 'to pull up one's gray-hair'	pat 'to pick up with fingers'
tic 'to be torn'	tuk 'to wriggle'	kətak 'to fall'
pəcit 'in the middle'	cuk 'to plug'	cap 'non-sense word'
kit 'non-sense word'	kut 'non-sense word'	pəkap 'to turn up side down'
ʔic 'excrement'	ʔup 'non-sense word'	ʔap 'watery'