การแปรของเสียงวรรณยุกต์ตามบริบทในภาษาลาวเวียงจันทน์

Contextual Tonal Variations in Vientiane Lao

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บทคัดย่อ

การศึกษานี้แสดงถึงผลการแปรทางกลสัทศาสตร์ ของระดับเสียงวรรณยุกต์ในระดับคำของภาษาลาวเวียงจันทน์ซึ่งอยู่ภายใต้อิทธิพลของวรรณยุกต์ในบริบทที่แตกต่างกัน รูปแบบการแปร ที่สามารถเกิดขึ้นได้มีทั้งหมด 25 คู่เสียง ซึ่งได้จากการบันทึกเทปเสียงวรรณยุกต์ 5 หน่วยเสียงของภาษาลาวเวียงจันทน์จากการวัดการเปลี่ยนแปลงของค่าความถี่มูลฐาน (F0) ค่าความถี่มูลฐานที่เกิดการเปลี่ยนแปลงไปนี้จะสะท้อนให้เห็นทิศทางและธรรมชาติการแปรของระดับเสียงวรรณยุกต์ในคำตามบริบทของภาษาลาวได้ กล่าวคือ เป็นไปได้หรือไม่ว่าระดับเสียงวรรณยุกต์ภาษาลาวจะได้รับอิทธิพลอย่างมากจากเสียงวรรณยุกต์ในคำที่มาก่อนหรือตามหลัง ซึ่งจะส่งผลกระทบต่อการกลมกลืนเสียงได้หรือไม่ ผลการศึกษาชี้ให้เห็นว่ารูปแบบการแปรของวรรณยุกต์ตามบริบทในภาษาลาวนั้นเกิดขึ้นเช่นเดียวกับที่เกิดขึ้นในภาษาอื่นๆ ที่มีระบบเสียงวรรณยุกต์ เสียงวรรณยุกต์ในคำที่มาก่อนจะส่งผลกระทบต่อขนาดและการขยายของเสียงมากกว่าเสียงผลกระทบจากเสียงวรรณยุกต์ในคำที่ตามมา อย่างไรก็ตาม เสียงวรรณยุกต์ที่มาก่อนนี้จะส่งผลต่อการกลมกลืนเสียง กล่าวคือ ค่าความถี่มูลฐานจะเพิ่มขึ้นเมื่อคำที่มาก่อนมีวรรณยุกต์ระดับสูงและจะต่ำลงเมื่อวรรณยุกต์ในคำที่มาก่อนมีระดับต่ำ ในทางตรงกันข้ามผลกระทบจากวรรณยุกต์ที่ตามมาจะไม่เกิดการกลมกลืนเสียงตามธรรมชาติมากนัก กล่าวคือ ค่าความถี่มูลฐานของวรรณยุกต์จะถูกทำให้ต่ำลงเมื่อตามหลังด้วยวรรณยุกต์ที่มีค่าความถี่มูลฐานที่สูงกว่า บางตำแหน่งจะเกิดการเปลี่ยนระดับหรือสูงขึ้นเมื่อมีเสียงวรรณยุกต์ที่มาก่อนมีค่าความถี่มูลฐานต่ำหรือในบางตำแหน่งของวรรณยุกต์ต่างระดับ

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Abstract

This study examines acoustic variations of lexical tones in Vientiane Lao under the influence of different tonal contexts. All 25 possible bitonal sequences from the five lexical tones in Lao are recorded, and their time course of fundamental frequency (F0) contours are measured. By examining the patterns of the F0 contours, this study explores the directionality and nature of contextual tonal variations in Lao: That is, it discusses whether Lao tones are more influenced by preceding tones (carryover effect) or by following tones (anticipatory effect) and whether these effects are assimilatory or dissimilatory. The results of this study indicate that the patterns of contextual tonal variation in Lao mostly agree with those in other tone languages. Carryover effects are greater in magnitude and extend farther into adjacent tones than anticipatory effects. Moreover, carryover effects are assimilatory: The onset of the F0 contour of a tone is raised when preceded by a tone with a high offset and lowered when preceded by a tone with a low offset. In contrast, anticipatory effects are mostly dissimilatory in nature: The F0 value of a tone is lowered when followed by a tone with a high F0 value somewhere in the contour and raised when preceded by a tone with a low F0 value somewhere in the contour.

Keywords: Lao, tone, F0 contour, contextual variation

1. Introduction

Vientiane Lao is a tone language spoken in Vientiane, the capital of Laos, with five lexical tones. Phonetic characteristics of Lao tones produced in isolation have been well studied and established in the literature (Crisfield, 1978; Osatananda, 1997; Ueda, 1994; Yanagimura, 2009). However, no instrumental study has been conducted on variations of Lao tones produced in context. This study examines fundamental frequency (F0) contour variations of Lao tones under the influence of different tonal contexts and shows that, in general, the patterns of contextual tonal variations in Lao agree with those previously reported in other tone languages.

1.1 Contextual tonal variations

Lexical tones in tone languages are known to have specific F0 contours as acoustic correlates. When produced in context, the F0 contours show certain phonetic variations depending on neighboring tones.

There are two important issues in the study of contextual tonal variation: directionality and the nature of the contextual effect. The issue of directionality is concerned with whether a tone is more influenced by preceding tones (carryover effect) or by following tones (anticipatory effect). In previous studies, it has been shown that, in general, the effect of a preceding tone is larger in magnitude and/or extends farther into adjacent tones than that of a following tone, indicating that tones are more influenced by carryover effects than by anticipatory effects (Mandarin: Xu, 1997; Thai: Gandour et al., 1994; Vietnamese: Brunelle, 2003). On the other hand, the nature of the contextual tonal effect is concerned with whether a tone assimilates or dissimilates to adjacent tones. It has been shown that carryover effects are assimilatory and anticipatory effects are dissimilatory (Mandarin: Xu, 1997; Thai: Gandour, et al. 1994).

1.2 Lao tones

In this study, the five Lao tones are referred to as Tones 1 to 5. A general description of the Lao tones is shown in Table 1, in which the canonical pitch patterns of the tones produced in isolation are described on a five-point scale (with 5 as the highest level).

Table 1 Lao lexical tones.

Label	Numeric scale	Example
Tone 1	33	k^{h}aa 'value'
Tone 2	31	k^{h}àa 'to kill'
Tone 3	451	k^{h}âa 'to trade'
Tone 4	34	k^{h}áa 'to be stuck'
Tone 5	215	k^{h}ǎa 'leg'

Source: Yu Yanagimura

Tone 1 is a mid level tone, which starts with a relatively high F0 value and falls slightly throughout the duration. Tone 2 is a mid falling tone, which falls throughout the duration from a higher mid F0 to the lowest F0 value. Tone 3 is a high rising-falling tone, which starts with a higher mid F0, rises to the highest F0, and then falls to the lowest F0 value. Tone 4 is a mid rising tone, which falls slightly in a mid F0 region in the earlier portion of the duration and rises to the end of the duration. Tone 5 is a low falling-rising tone, which starts with a relatively low F0, falls to the lowest F0, and rises to the highest F0 value.

Tone 5 has the lowest onset value of the five tones; the onsets of Tones 1 to 4 have approximately the same height in a relatively high F0 region. Tones 1 to 5 have intermediate, low, low, high, and high offsets respectively when produced in isolation. However, when produced with a following syllable, Tone 3 does not fall in the later portion of the duration as when produced in isolation, and its offset has a higher F0 value than that of other tones; also, Tone 5 does not rise in the later portion of the duration as when produced in isolation, and its offset has a lower F0 value than that of other tones.

2. Method

We recorded controlled speech materials produced by native speakers, then measured and analyzed their time course of F0 contours.

2.1 Materials

In this study, 25 nonsense forms were used. They were created by combining segmental sequences /maalaa/ with all 25 possible bitonal sequences from the five Lao tones. By means of a comparison among five kinds of bitonal sequences, Tone 1–Tone 1, Tone 1–Tone 2, Tone 1–Tone 3, Tone 1–Tone 4, and Tone 1–Tone 5, for example, the variation of Tone 1 in the first syllable /maa/ caused by five different tones in the second syllable /laa/ can be observed.

In order to make the 25 nonsense forms as natural as possible, they were each produced as a person's name in the carrier sentence *Láaw sμμ ___ mɛɛn bɔɔ?* 'Is his name ___?' All four native speakers of Lao who participated in the present study reported the nonsense forms to be as natural as Lao in this carrier sentence.

2.2 Recordings

Four native speakers of Lao, three females and one male, participated in the recordings. At the time of recording, the speakers were all in their twenties or thirties and were undergraduate or graduate students studying at universities in Japan. They were all born and raised in Vientiane city, Laos. None of the speakers reported having speech or hearing problems.

A list of 80 sentences, including 25 sentences described in Section 2.1 and five dummy sentences, was read twice by each participant. The target sentences appeared three times each at random. Three of the dummy sentences were read at the beginning of the list, while the remaining two were

included at the end. The speakers were asked to make all their productions as natural as possible so that no pauses were inserted between two syllables.

The recordings were conducted in reasonably quiet rooms using a Marantz PMD 660 digital recorder and AKG acoustics C420PP microphone (16-bit, 44.1 kHz). From these recordings, 600 utterances (25 sentences × 6 repetitions × 4 speakers) were collected, and 568 utterances were analyzed after elimination of 32 utterances that had been read incorrectly or in a creaky voice.

2.3 Measurements

F0 was measured using Praat (ver. 5.1.07). In a simultaneous display of the waveform and wide-band spectrogram of each /maalaa/ sequence, every vocal pulse and the onset and offset of each segment were marked. The intervals between successive vocal pulses were then transformed into F0 values by a Praat script (Xu 2009). From the obtained F0 curves, several F0 values were measured: F0 values at every 20% of the duration of each consonant and at every 10% of the duration of each vowel, which were used for display and visual inspection, and F0 values at every 50% of the duration of each consonant and at every 25% of the duration of each vowel, which were used for statistical analysis.

3. Results and discussion

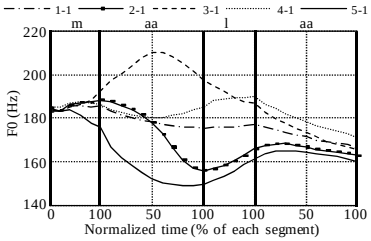
Examination of the F0 contours of the /maalaa/ sequences in individual speakers found essentially the same patterns as in the F0 contours averaged over speakers in terms of directionality and the nature of contextual effects. Therefore, only results of analyses pooled across speakers are reported. I will first describe carryover and anticipatory effects of Lao tones in Sections 3.1 and 3.2, respectively. Finally, by means of a comparison

between these two effects, the issue of the directionality of contextual tonal effects in Lao will be discussed in Section 3.3.

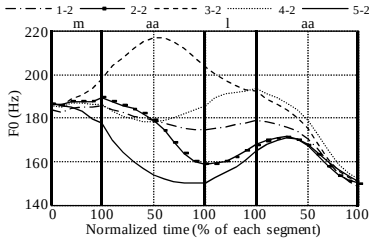
3.1 Carryover effects

Figure 1 shows F0 contour variations of the five Lao tones when they are preceded by five different tones in the /maalaa/ sequences. Each panel in the figure plots the same tone in the second syllable /laa/ and different tones in the first syllable /maa/. For example, Figure 1(a) shows five F0 curves that contain Tone 1 in the second syllable and five different tones in the first syllable. Each curve was obtained first by averaging over all repetitions (with a maximum of six repetitions) of each bitonal sequence produced by each speaker, then by averaging over all four speakers. The time scale is equalized for all the curves, and a consonant is plotted with five points, while a vowel is plotted with ten points.

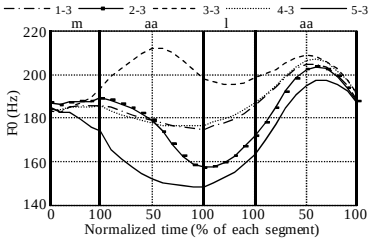
Examination of each panel in Figure 1 reveals that the F0 contour of a given tone in the second syllable varies according to the preceding tone. For example, at the onset of the second syllable (the onset of /l/), the F0 value of Tone 1 (Figure 1(a)) shows a 48 Hz difference between the highest value (after Tone 3: 197 Hz) and the lowest value (after Tone 5: 149 Hz). In the same way, it exhibits a 28 Hz difference at the onset of the vowel in the second syllable, 14 Hz difference at the midpoint of the vowel, and 11 Hz difference at the offset of the vowel, indicating a gradual reduction of carryover effects over time. This kind of F0 variation in the second syllable according to the preceding tone is seen in all five tones, although the magnitude of variation differs according to the tone of the second syllable. When pooled across tones in the second syllable, the F0 difference in the second syllable, due to the preceding tone, is 51 Hz at the onset of the syllable, 29 Hz at the onset of the vowel, 11 Hz at the midpoint of the vowel, and 4 Hz at the offset of the vowel.



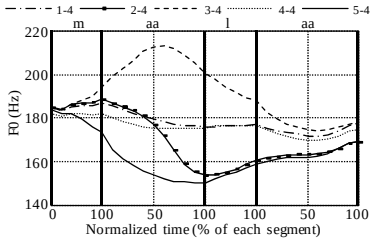
(a) Tone 1



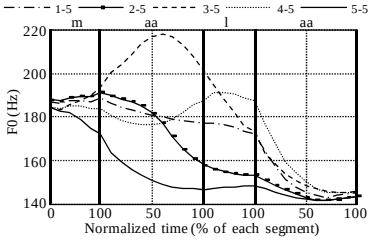
(b) Tone 2



(c) Tone 3



(d) Tone 4



(e) Tone 5

Figure 1 Carryover effects of the preceding tone on the F0 contour of the following tone in /maalaa/ sequences in Lao. Each panel plots the same tone in the second syllable (Tones 1 to 5 in (a) to (e) respectively) and five different tones in the first syllable. Bold vertical lines indicate segmental boundaries. Each curve is the unweighted mean obtained first by averaging over all repetitions (with a maximum of six repetitions) of each speaker, then by averaging over all four speakers.

The nature of the carryover effects can be considered as assimilatory to the offset value of the preceding tone; that is, the onset of the tone of the second syllable is raised when preceded by a tone with a high offset, while it is lowered when preceded by a tone with a low offset. This tendency is suggested by the following fact: The descending order of the offset values of the five tones is as follows: Tone 3, 4, 1, 2, and 5 (see the offset of the second syllable in each panel of Figure 2 below). For the onset of the second syllable, the same order can be established. For example, the onset value of Tone 1 in the second syllable is higher when the preceding syllable has Tone 3 or 4, both of which have a relatively high offset, than when it has any other tone; it is lower when the preceding syllable has Tone 2 or 5, both of which have a relatively low offset; and it is intermediate when the preceding syllable has Tone 1, which has a mid offset. The same is true of the other four tones (except for the sequences Tone 4–Tone 3 and Tone 4–Tone 4, in which the offset value of Tone 4 in the first syllable is no more than that of Tone 1 due to anticipatory effects discussed in Section 3.2). Therefore, it can be concluded that the onset value of a tone in the second syllable assimilates to the offset value of the preceding tone.

In order to examine the carryover effects statistically, a set of two-way repeated-measure ANOVAs was conducted. The independent variables were the tone of the first syllable (Preceding tone: Tone 1–Tone 5) and the tone of the second syllable (Tone: Tone 1–Tone 5), while the dependent variables were the F0 values measured at seven positions in the second syllable (0% and 50% of the duration of the consonant, 0%, 25%, 50%, 75%, and 100% of the duration of the vowel).

Table 2 shows *F* and *p* values of the main effects and the two-way interaction revealed by the ANOVAs. The main effect of Preceding tone is significant at all seven positions ($p < 0.01$ at all the positions), indicating that carryover effects of the tone of the first syllable extend throughout the following syllable. In addition, the interaction between Preceding tone and Tone is significant at all seven positions ($p < 0.05$ at 50% of the vowel and $p < 0.01$ at the other six positions), suggesting that the magnitude of carryover effects differs depending on the affected tone. For example, as can be inferred from Figure 1, the final portions of Tones 1 and 4 in the second syllable seem to be more affected by carryover effects than those of Tones 2, 3, and 5.

Table 2 ANOVA results for the effects of Preceding tone and Tone at seven positions in the second syllable of the sequence /maalaa/. Bolded *p* values indicate significant effects.

		Position						
		Consonant		Vowel				
Effect		0%	50%	0%	25%	50%	75%	100%
Preceding tone	*F*(4, 12)	39.05	31.31	24.33	15.68	9.63	8.64	5.68
	p	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**0.001***	**<0.001***	**<0.001***
Tone	*F*(4, 12)	5.31	12.91	72.59	217.42	146.52	85.03	41.60
	p	**0.011***	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***
Preceding tone × Tone	*F*(16, 8)	3.95	9.23	13.74	4.04	2.16	2.97	3.48
	p	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**0.020***	**<0.001***	**<0.001***

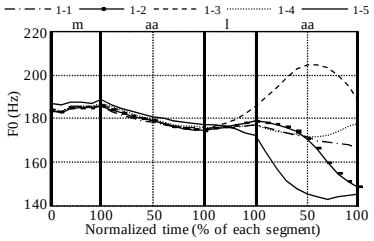
3.2 Anticipatory effects

Figure 2 shows F0 contour variations of the tones when followed by five different tones in the /maalaa/ sequences. The F0 curves in the figure are

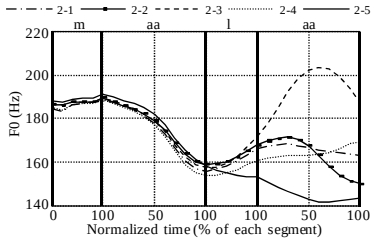
the same as in Figure 1, but arranged in such a way that five F0 curves in each panel contain the same tone in the first syllable and five different tones in the second syllable.

In the first syllable, as can be seen in Figure 2, the F0 contours of the tones are rather stable and undergo few variations depending on the following tone. Pooled across tones of the first syllable, the F0 difference in the first syllable due to the following tone was not more than 4 Hz in any location in the syllable. Compared with carryover effects, the magnitude of F0 variations caused by anticipatory effects is smaller throughout the syllable.

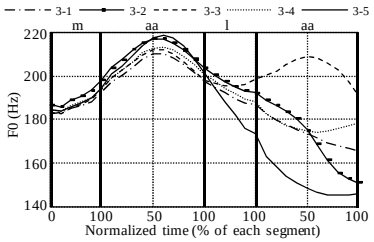
Although the magnitude of variations is small, the anticipatory effects seem to be dissimilatory in nature. F0 variations due to anticipatory effects can be seen most clearly when the first syllable has Tone 3 or 4. In the case of Tone 3 (Figure 2(c)), the overall F0 is slightly higher when the following syllable has Tone 2 or 5, both of which have a low F0 value somewhere in the F0 contour (not necessarily at the onset) than when it has any of the other three tones, all of which do not have a low F0 value in the F0 contour. In the case of Tone 4 (Figure 2(d)), the offset value is lower when the following syllable has Tone 3 or 4, both of which have a high F0 value somewhere in the F0 contour (again, not necessarily at the onset) than when it has any of the other three tones, all of which do not have a high F0 value in the F0 contour. Also, pooled across tones of the first syllable, the average F0 value of the first syllable is slightly higher when the following syllable has Tone 2 or 5 than when it has any of the other tones in any position in the syllable. These observations suggest that the anticipatory effects are dissimilatory; that is, a tone with a low F0 value somewhere in the F0 contour raises the F0 of the preceding syllable, and a tone with a high F0 value somewhere in the F0 contour lowers the F0 of the preceding syllable.



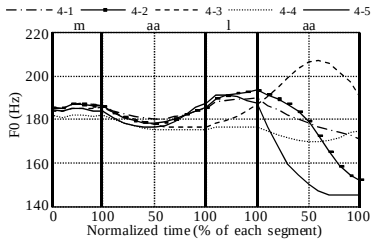
(a) Tone 1



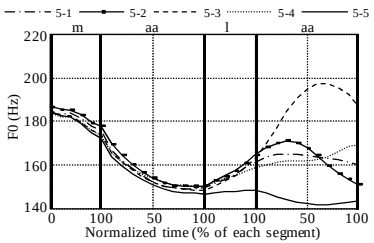
(b) Tone 2



(c) Tone 3



(d) Tone 4



(e) Tone 5

Figure 2 Anticipatory effects of the following tone on the F0 contour of the preceding tone in the /maalaa/ sequences in Lao. Each panel plots the same tone in the first syllable (Tones 1 to 5 in (a) to (e) respectively) and five different tones in the second syllable. Bold vertical lines indicate segmental boundaries. Each curve is the unweighted mean obtained first by averaging over all repetitions (with a maximum of six repetitions) of each speaker, then by averaging over all four speakers.

To examine the anticipatory effects statistically, a set of two-way repeated-measure ANOVAs was conducted. The independent variables were the tone of the second syllable (Following tone: Tone 1–Tone 5) and that of the first syllable (Tone: Tone 1–Tone 5), while the dependent variables were the F0 values measured at seven positions in the first syllable (0% and 50% of the duration of the consonant, 0%, 25%, 50%, 75% and 100% of the duration of the vowel).

Table 3 shows *F* and *p* values of the main effects and the two-way interaction revealed by the ANOVAs. The main effect of Following tone is significant at 75% and 100% of the duration of the vowel in the first syllable ($p < 0.05$ for both positions). This indicates that, although only in the final portion of the first syllable, the tone of the second syllable exerts dissimilatory effects on the preceding tone. There is also a significant interaction between Following tone and Tone at four positions from 25% to 100% of the duration of the vowel ($p < 0.01$ at all four positions). This suggests that the magnitude of F0 variations caused by anticipatory effects differs by the affected tone. Because the largest anticipatory effects seem to be in the high F0 regions of Tones 3 and 4, as mentioned, it may be the case that a high F0 value in a tonal contour is more susceptible to anticipatory effects than a mid or low F0 value.

Table 3 ANOVA results for the effects of Tone and Following tone at seven positions in the first syllable of the sequence /maalaa/. Bolded p values indicate significant effects.

		Position						
		Consonant		Vowel				
Effect		0%	50%	0%	25%	50%	75%	100%
Tone	*F*(4, 12)	0.97	3.15	21.60	99.31	126.80	71.20	39.05
	p	0.459	0.055	**<0.001***	**<0.001***	**<0.001***	**<0.001***	**<0.001***
Following tone	*F*(4, 12)	1.40	1.33	1.62	1.42	1.35	4.16	5.31
	p	0.293	0.313	0.233	0.286	0.307	**0.024***	**0.011***
Tone × Following tone	*F*(16, 48)	1.03	1.42	1.47	3.07	3.16	3.07	3.95
	p	0.443	0.171	0.149	**0.001***	**0.001***	**0.001***	**<0.001***

3.3 Directionality of contextual effects

With respect to the directionality of contextual effects of tones, it can be said that Lao tones are more influenced by preceding tones than by following tones. The magnitude of F0 variations due to carryover effects is larger than anticipatory effects throughout the length of the affected syllable. Furthermore, carryover effects are more extensive than anticipatory effects. Carryover effects extend forward to the end of the following syllable, whereas anticipatory effects extend backward to 75% of the duration of the preceding vowel. Therefore, as far as the magnitude and the temporal extent of effects are concerned, carryover effects are stronger than anticipatory effects in Lao tones.

4. Conclusion

This study observed variations of Lao tones due to the influences of adjacent tones, showing that carryover effects on tones are larger in

magnitude and extend more into adjacent syllables than anticipatory effects. The nature of the carryover effects is assimilatory; that is, a tone with a high offset raises the onset of the following tone, and a tone with a low offset lowers the onset of the following tone. In contrast, the anticipatory effects are dissimilatory; that is, a tone with a low F0 value somewhere in the F0 contour raises the F0 of the preceding tone, and a tone with a high F0 value somewhere in the F0 contour lowers the F0 of the preceding tone. These patterns of contextual variation in Lao tones mostly agree with the cross-linguistically recurrent patterns reported in previous works. Therefore, further studies should investigate whether the contextual variations observed in these various languages are attributed to certain common mechanisms, and if so, which ones.

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