Nonword Repetition of Taiwanese Disyllabic Tonal Sequences in Adults with Language Attrition

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Abstract

This study demonstrates the nonword repetition format comparable to other conventional tasks (picture-naming, reading, and so on) as a plausible measure of linguistic competence for adults with language attrition. Taiwanese speakers with and without attrition symptoms, defined by frequency of use, were recruited, and so were American learners of Mandarin Chinese. The results show that (1) fluent speakers' repetition accuracy of Taiwanese tones is significantly higher than attrition speakers', and American learners' is the worst, (2) among five target tones (high-level, low-rising, low-falling, high-falling and mid-level), the repetition accuracy of high-falling tone is the highest, and that of low-level tone is the lowest in non-word-final position across the three participant groups, and (3) the least accurate mid-level tone tends to be mispronounced as low-rising. The findings suggest that the participants' frequency of use and exposure to Taiwanese is positively correlated with the repetition accuracy, and mid-level tone is the most difficult category to learn. More crucially, the percent accuracy and confusion matrix of nonword repetition enlighten how mid-level tone is more susceptible to sound change.

Index Terms: speech production, nonword repetition, Taiwanese tones, language attrition, mid-level tone

1. Introduction

The nonword repetition format is conventionally adopted to evaluate linguistic competence for children and adults with specific language impairment (SLI), as shown in [1, 2, 3, 4]. The task arguably requires participants to apply their temporary phonological storage and short-term memory, so the repetition accuracy may indicate a potential defect of phonological encoding and other post-lexical processes governed by the competence required. Although Sasisekaran et al [4] and Gathercole [5] suggest that nonword repetition may tap each level of processing, from auditory decoding and lexical retrieval to motor planning and phonetic implementation, its requirement for temporary phonological storage boosts the extensive use for pathological purposes. However, Gathercole [5] relates nonword repetition to language learning by arguing that the competence of temporary phonological storage is an onset stage of language learning. The processing of nonword repetition is somehow similar to that of language learning. The argument rationalizes a non-pathological use of nonword repetition as we focus on Taiwan Southern Min speakers (hereafter referred to as Taiwanese) with language attrition in this study.

As indicated by Paradis [6], language attrition results from a bilingual context where speakers reduce frequency of use in a dominated language. It becomes a serious issue in Taiwan,

as Hsiao [7] finds that Mandarin-Taiwanese bilinguals, especially younger speakers, no longer speak Taiwanese at home and even in rural areas, where most Taiwanese speakers acquire their mother tongue. Language attrition not only leads to a dramatic population decline in the speech community, but also causes individuals to undergo attrition symptoms. For instance, Yeh & Tu [8] demonstrate that Taiwanese speakers with language attrition (hereafter referred to as attriters) were found to commit more tonal errors than fluent speakers in both perception and production tasks. In addition, mid-level tone was found to be the least accurate category among five target tones (Tone55: high-level tone, Tone24: low-rising, Tone21: low-falling, Tone51: high-falling and Tone33: mid-level) illustrated in Table 1. As to the confusion matrix, both attriters and fluent speakers tend to mispronounce mid-level tone as low-falling in the production task, but they tend to misperceive the least accurate category as high-level, indicating an asymmetry between perception and production processes. Yeh & Tu [8] argue that the asymmetry may result from a post-lexical influence of tone sandhi. In order to verify the attrition effect on tonal processing and the asymmetry, we try the nonword repetition format to examine whether the confusion matrix of mid-level errors in nonword repetition mediated by both perception and production conform to the perceptual tendency or the production one.

Table 1. *Five target tones in Yeh & Tu [8]. (H= high, L= low, M= mid; 5= the highest pitch, 1= the lowest)*

Contour	Height	Example	Gloss
Level	H	膚 hu55	skin
Rising	L	扶 hu24	to support
Falling	L	赴 hu21	to catch
	H	撫 hu51	to console
Level	M	傅 hu33	master

2. Research questions

In order to examine the effects of language attrition on attriters' linguistic competence and the causes of perception-production asymmetry, we ask four research questions as follows: first, whether the effect of language attrition causes attriters to commit more nonword repetition errors than fluent speakers (an attrition effect); second, whether repetition accuracy of actual words is higher than that of nonwords (a lexical effect); third, whether mid-level tone is the least accurate category; fourth, whether mid-level errors tend to be mistakenly repeated as low-falling tone (production tendency) or high-level tone (perceptual tendency).

First, as found by Yeh & Tu [8], language attrition causes attriters to undergo tonal misperceptions and mispronunciations, suggesting a negative impact on tonal

processing. As indicated by Sasisekaran et al [4] and Gathercole [5], the processing of nonword repetition involves many levels of psychological processing, which are also susceptible to the effects of language attrition. As a result, the effect of language attrition is predicted to induce more nonword repetition errors in attriters than in fluent speakers.

Second, Saito et al [1] and Munson et al [2] find that the wordlikeness (phonotactically legal and illegal) and the token frequency (high and low) exert a significant influence on nonword repetition accuracy: the repetition accuracy is higher in phonotactically-legal and high-frequency stimuli than illegal and low-frequency ones, suggesting a lexical effect. As a result, repetition accuracy of actual words is predicted to be higher than that of nonwords.

Third, Yeh & Tu [8], Yeh & Lu [9] and Hong [10] find that non-high-level tone is one of the most confusing categories in Taiwanese as well as in many other Chinese languages, such as Cantonese, Hakka and Singapore Hokkien. It is phonetically similar to high-level tone in pitch contour and is similar to low-falling tone and low-rising tone in pitch height, which makes it less perceptually distinctive than any other. As a result, nonword repetition accuracy of mid-level tone is predicted to be lower than that of any other.

Fourth, Yeh & Tu [8] find that Taiwanese attriters tend to mistakenly decode mid-level tone as high-level tone or low-falling tone in tonal processing, so they are also likely to make repetition errors in the same manner. In other words, mid-level tone is predicted to be mistakenly repeated as high-level tone or low-falling tone.

3. Methods

In order to answer the four research questions above, the four independent variables (degrees of language attrition as frequency of use in Taiwanese, word types, the first syllable's tone types as targets, and the second syllable's tone types as neighbors) were set up in the following experiment.

3.1. Participants

We recruited three groups of participants as three levels of attrition variables (defined by frequency of use), and should have included Mandarin monolinguals and naïve Americans as a contrast. The three groups are fluent Taiwanese speakers, Taiwanese attriters and American learners of Mandarin Chinese. There were five participants for each group in this preliminary investigation. The fluent speakers (3 males, 2 females; mean age: 31.4 yrs) were recruited in the States, and they speak Taiwanese on a daily basis. The attriters (2 males, 3 females; mean age: 32.4 yrs) were also recruited in the States. They used to speak Taiwanese at home, but they no longer do so in the recent decade. They mostly speak Mandarin nowadays, and use Taiwanese once a month or even less frequently. The American students (3 males, 2 females; mean age: 19.2 yrs) were recruited from the University of Colorado Boulder, and they had learned Mandarin for more than 150 hours at the time of doing the repetition task. They had never exposed themselves to Taiwanese before.

3.2. Stimuli

Except for the attrition variable, the other three variables (word types, targets' tone types and neighbors' tone types) were set up in 100 disyllabic stimuli. The stimuli were set up by two word types (actual words, phonotactically legal nonwords), five tone types (high-falling, low-rising, low-falling, high-falling and mid-level, as shown in Table 1) for the first syllable (non-word-final), five tone types as in the second syllable (word-final), and two syllables (not a variable; [ti] and [hu] for actual words; [ʂu] and [nu] for nonwords), 2 x 5 x 5x 2= 100, for example: [ti21-sɛ21] 治世 'to manage the world' and [hu21-tsɛ21] 負債 'owe a debt' as two syllable types for actual words, and [ʂu21-ti21] and [nu21-ti21] as two syllables for nonwords. The 100 stimuli were recorded by a female Taiwanese speaker with a major in linguistics.

3.3. Nonword repetition task

In the task, each participant was instructed to repeat exactly what they just heard from the headphone. They had five training trials to practice before the task. There are 200 trials (100 stimuli x 2 repetitions) total. The task is all self-paced, and they may have a five-minute break in the half.
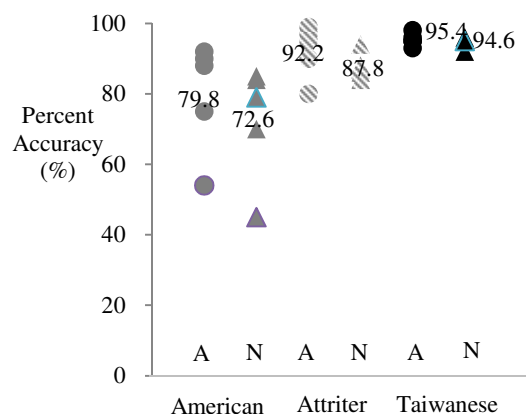
4. Results

The repetition results were rated perceptually by two investigators who are both fluent Taiwanese speakers. Their ratings were mutually examined and corrected, and the inter-rater reliability was about 95%. The investigators analyzed both tonal and segmental accuracy, and only the tonal accuracy of target tones (the first syllable) was counted in the preliminary analysis. As to each participant, their repetition results were analyzed in 50 tokens (2 word types x 5 target tones x 5 neighbor tones), and each token was calculated by four counts (2 syllable types x 2 repetitions). These counts were concluded in a descriptive manner below in section 4.1, and then were analyzed statistically in section 4.2.

4.1. Preliminary analysis

The percent accuracy of nonword repetition is illustrated in Figure 1 and Figure 2 below.
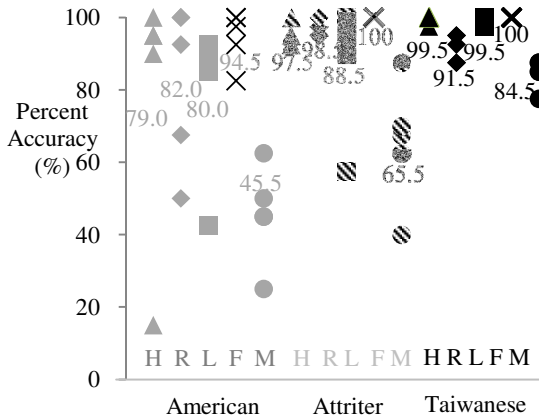
Figure 1: *Nonword repetition accuracy in participants and word types (A: actual words, N: nonwords).*

As shown in Figure 1, the nonword repetition accuracy of fluent Taiwanese speakers (mean: 95.4/94.6) is higher than that of attriters (mean: 92.2/87.8), and the accuracy is the lowest in American learners of Mandarin (mean: 79.8/72.6). The results support the effect of language attrition (frequency of use) on nonword repetition. In addition, the accuracy of actual words (mean: 95.4/92.2/79.8) is higher than that of

nonwords (mean: 94.6/87.8/72.6) across the three participant groups, indicating a lexical effect.

Figure 2: *Nonword repetition accuracy in participants and tone types (H: high-level, R: low-rising, L: low-falling, F: high-falling, M: mid-level).*

As shown in Figure 2, the nonword repetition accuracy of high-falling tone (F, mean: 94.5/100/100) is higher than any other tone, and the accuracy is the lowest in mid-level tone (M, mean: 45.5/65.6/84.5), indicating mid-level tone as the most confusing category in nonword repetition. As to the neighbors' tone types, the results show that repetition accuracy of target tones is lower when the first syllable (non-word-final) precedes low-rising tone than any other neighbor. However, this finding should be interpreted with caution, since participants tend to mistakenly repeat mid-level tone as rising in the word-final position for some reason.

4.2. Regression analysis

The nonword repetition accuracy was further analyzed by a linear multiple regression model as in (1). **Y** refers to repetition accuracy of each stimulus token; **a** (the constant value) refers to an intercept; and **b** (**b₁** to **b₁₁**) refer to a regression coefficient. L, W, T and C are dummy variables set up for various levels of independent variables.

$$Y= a+ b_1*L_1+ b_2*L_2+ b_3*W+ \quad (1)$$
$$b_4*T_1+ b_5*T_2+ b_6*T_3+ b_7*T_4+$$
$$b_8*C_1+ b_9*C_2+ b_{10}*C_3+ b_{11}*C_4$$

The multiple regression analysis indicates a significant difference in the nonword repetition task, $R^2= 0.2765$, $F(11,738)= 35.244$, $p< 0.001***$. The analysis of each variable is demonstrated in Table 2. As to the attrition variable (frequency of use, degree of exposure), the repetition accuracy of both fluent speakers and attriters is significantly higher than that of American learners (L_1, L_2 respectively), and the accuracy of fluent speakers is also higher than that of attriters, supporting the effect of language attrition on nonword repetition mediated crucially by phonological storage and post-lexical processes. As to the word types (W), the repetition accuracy of actual words is also significantly higher than that of nonwords.

As to the targets' tone types, the accuracy of high-level tone, low-rising tone, low-falling tone and mid-level tone is significantly lower than that of the most accurate high-falling

tone (T_1, T_2, T_3, and T_4 respectively), and the accuracy of mid-level is the lowest, supporting the prediction above. As to the neighbors' tone types, the accuracy of low-rising neighbors is significantly lower than that of high-falling (C_2), and the accuracy of high-level, low-falling and mid-level neighbors is not significantly different from that of high-falling (C_1, C_3 and C_4 respectively).

Table 2. *Results of multiple regression analysis of each variable (*<0.05, **<0.01, ***<0.001).*

Variable	Level	t-value	p-value
Attrition degrees	L_1	-9.327	<***
	L_2	-2.481	<*
Word types	W	2.511	<*
Targets' tone types	T_1	-2.370	<*
	T_2	-2.882	<**
	T_3	-3.394	<***
	T_4	-12.681	<***
Neighbors' tone types	C_1	1.793	>0.05
	C_2	2.562	<*
	C_3	1.345	>0.05
	C_4	1.153	>0.05

4.3. Confusion matrix of mid-level tone

The repetition errors of the least accurate mid-level tone are further analyzed and illustrated below. The table shows four error patterns of mid-level tone in the substitute column, and two most likely neighbors of each error pattern in the neighbor column. For instance, American learners mistakenly repeated mid-level tone as high-level for 15 times in total. 7 out of 15 high-level errors of mid-level tone occurred before low-rising tone, 4 out of 15 before high-level tone, and the rest (4=15-7-4) before three other neighbors.

Table 3. *Repetition errors (subs.= substitute) of mid-level tone with neighbors (T55: high-level, T24: low-rising, T21: low-falling, T51: high-falling, T33: mid-level).*

Groups	Subs. (1st)		Neighbors (2nd syllable)			
American	T55	15	T24	7	T55	4
	T24	**46**	T21	17	T24	14
	T21	26	T51	11	T55	6
	T51	21	T55	13	T24	5
Attriter	T55	16	T21	8	T55	5
	T24	**48**	T51	25	T55	17
	T21	8	T21	3	T33	3
Taiwanese	T55	6	T33	3	T21	2
	T24	**22**	T51	19	T21	2
	T21	4	T55	2	T21	1

As shown in Table 3, all participants tend to mistakenly repeat mid-level tone as low-rising tone (46, 48 and 22 errors respectively). Then Taiwanese fluent speakers and attriters prefer high-level tone to low-falling tone as substitutes for mid-level tone (high-level: 16, 6> low-falling: 8, 4), but not the group of American learners (high-level: 15< low-falling: 26). As to the neighbors of the more preferable low-rising substitutes, Taiwanese fluent speakers and attriters tend to mistakenly repeat mid-level tone as low-rising tone before high-falling tone (19 and 25 errors respectively), but American learners do so before low tones (low-falling and low-rising, 17and 14 errors).

5. Discussion

First, the results of nonword repetition show that fluent Taiwanese speakers commit fewer tonal errors than attriters, and American learners with no Taiwanese exposure commit more tonal errors than any other. The finding supports the effect of language attrition on nonword repetition of Taiwanese tonal processing, which is arguably mediated by temporary phonological storage and short-term memory, and suggests that language attrition, induced by decreasing frequency of use, not only interferes with attriters' tonal perception and production [8, 9], but also inhibits their access to short-term memory and phonological storage.

Second, the results show that the repetition accuracy of actual words is higher than that of phonotactically legal nonwords across the three groups. The finding suggests a lexical effect on nonword repetition of Taiwanese tones. However, it seems contradictory why there is a lexical effect on American learners who had no Taiwanese exposure before. A potential lexical influence from Mandarin or an intrinsic difficulty in syllable structures may account for the lexical effect on American learners' repetition accuracy. That is, the four syllables of current stimuli ([ti] and [hu] for actual words; [ʂu] and [nu] for nonwords) happen to have corresponding meanings in Mandarin, for example: [ti51] 'brother', [hu51] 'to protect', [ʂu51] 'tree' and [nu51] 'wrath'. All participants did not know what language they were instructed to repeat beforehand, so it is likely for them to rely on their Mandarin experience in processing of nonword repetition. The token/lexical frequency of actual words, 'brother' is higher than the others, and that of nonwords 'wrath' is the lowest. In addition, the retroflex onset of nonwords 'tree' is difficult for American learners to learn. The two potential factors might account for the lexical effect on American learners' repetition accuracy.

Third, the results show that the repetition accuracy of mid-level tone is lower than any other tone across the three groups. The finding indicates that mid-level tone is the most difficult category to be repeated among five target tones in Taiwanese, and suggests that mid-level tone is difficult to be processed and represented in short-term memory/temporary phonological storage. As suggested by Gathercole [5], the temporary phonological storage is an onset stage of language learning, and it remains available to support word learning across the life span. Since mid-level tone is difficult to be processed in temporary phonological storage, it seems less likely to be acquired easily and accurately, and it is more susceptible to sound change, confirming previous findings [8, 9, 10].

Fourth, the confusion matrix of mid-level tone shows that mid-level tone tends to be mistakenly repeated as low-rising tone. The finding indicates that the repetition errors do not conform to either a perceptual tendency (as high-level tone) or an articulatory tendency (as low-falling tone), and suggests that the nonword repetition processing may not necessarily rely on the sensor-motor mechanisms/language systems throughout. The finding seems to support Gathercole [5] and many others' argument that nonword repetition can be crucially mediated by short-term memory and temporary phonological storage. In addition, as suggested by the repetition errors of mid-level tone as low-rising, pitch height tends to remain faithful in short-term memory, but pitch contour does not. The mid-level errors' pitch contour seems to be determined by its neighbors' tone types. As preceding high tones (high-falling, high-level), mid-level tone is more likely to rise in offset pitch for tonal co-articulation. The findings suggest that mid-level tone tends to be mistakenly repeated as low-rising tone for both phonetic and phonological reasons.

6. Conclusions

This study demonstrates a non-pathological use of nonword repetition in adult speakers with language attrition as well as in second language learners. The current results show that Taiwanese attriters and American learners of Mandarin encounter significantly more tonal errors than fluent speakers in word and nonword repetition of Taiwanese disyllabic tonal sequences, suggesting that the nonword repetition format can be an appropriate method as well as other conventional tasks (discrimination, picture-naming and so forth) to examine some linguistic competence, temporary phonological storage in particular, of adult speakers without SLI. However, some of these preliminary findings should be interpreted with caution due to a relatively small number of participants and some potential confounding variables as mentioned earlier. As the nonword repetition method is proved to be legitimate in a non-pathological use, we expect to minimize these preliminary issues for a further extension.

8. References

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