

A phonetic study of the “er-hua” rimes in Beijing Mandarin

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Abstract

The paper is the acoustical, articulatory, and physiological investigation of the phonetic changes of the “er-hua” rimes, i.e., the rimes affixed with the diminutive suffix “er” [ə] ‘child’, in Beijing Mandarin. Acoustically, all the [ə]-suffixed rimes have a low F₃ value, as an indication of being rhotacized. The other changes of the rimes after [ə]-suffixation vary, depending on the type of component segments of the rimes. The rimes are added with a sub-syllabic [ə], when the rimes end with a non-back vowel. When the rimes end with a back vowel, no [ə] is added to the rimes and the whole of the rimes becomes rhotacized. For the rimes which contain a diphthong or triphthong with a final vowel element [i] or [e], the final vowel element is deleted. For the rimes which end with an alveolar [n], the nasal ending is deleted. For the rimes which end with a velar [ŋ], the nasal ending is also deleted and the whole of the rimes is nasalized.

1. Introduction

This is a phonetic study of the changes of the “er-hua” rimes, i.e., the rimes affixed with the diminutive suffix “er” [ə] ‘child’, in Beijing Mandarin (BM, henceforth). The [ə]-suffixation is called “er-hua” in Mandarin Chinese. According to the classic BM studies by Y.R. Chao ([1, 2]), the diminutive suffix is a non-syllabic morpheme and considered as a retroflex ending. When a syllable affixed with the diminutive retroflex suffix, the suffix does not form an additional syllable and the rime of the preceding root syllable is added with r-coloring. The exact changes of the [ə]-suffixed rimes vary, depending on the type of component segments of the rimes, which are in turn determined by whether the articulations of the segments of the rimes and the diminutive retroflex suffix are compatible. The rimes which end with a back or low vowel are said to be compatible with the diminutive retroflex suffix. In this case, the rimes and the suffix are telescoped together and the rimes become retroflexed. For the rimes which end with a front vowel, they are considered incompatible with the diminutive retroflex suffix. In this case, the rimes are suffixed with a retroflexed ending. In the case where the rimes end with a nasal [n] or [ŋ], the nasal ending is deleted. But, for the rimes with a velar nasal ending [ŋ], the nasality is retained and the whole of the rimes is nasalized. The description of the changes of the [ə]-suffixed rimes presented in Chao’s studies ([1, 2]) has not been substantiated by objective data. The present study is a comprehensive investigation of the phonetic and morpho-phonological changes of the [ə]-suffixed rimes in BM by obtaining the acoustical, articulatory, and physiological data.

2. Method

The test monosyllables consisting of all types of rimes in BM that undergo [ə]-suffixation were analyzed. For comparison purpose, the same monosyllables containing the plain rime, i.e., the rime which has not been [ə]-suffixed, were also analyzed. In BM, there are five types of rimes, where the rimes may be the

monophthongs [i, ɿ, ʅ, y, u, ɤ, a], diphthongs [ie, ye, ei, ai, ia, ua, au, uo, ou], triphthongs [iau, iou, uei, uai], sequences of ‘vowel+nasal’ [in, in̩, yn, un̩, ən, əŋ, an, aŋ], or sequences of ‘diphthong+nasal’ [ien, iaŋ, yen, iuŋ, uən, uan, uaŋ]. In this study, the test monosyllables which contain a monophthong include [tʃei ʅ] ‘chicken’, [sɿ ʅ] ‘silk’, [tʃʅ ʅ] ‘branch’, [y ʅ] ‘fish’, [tʃʰa ʅ] ‘crotch’, [tʃu ʅ] ‘pearl’, and [kɤ ʅ] ‘song’. The test monosyllables which contain a diphthong include [tʃie ʅ] ‘street’, [ɕye ʅ] ‘boots’, [pei ʅ] ‘tablet’, [pʰai ʅ] ‘board’, [ɕia ʅ] ‘box’, [xua ʅ] ‘flower’, [pau ʅ] ‘bag’, [xuə ʅ] ‘livelihood’, and [tʰou ʅ] ‘head’. The test monosyllables which contain a triphthong include [tʰiau ʅ] ‘strip’, [tʃʰiou ʅ] ‘ball’, [tʃʰuei ʅ] ‘hammer’, and [kʰuai ʅ] ‘piece’. The test monosyllables which contain a sequence of ‘vowel+nasal’ include [ɕin ʅ] ‘heart’, [ɕin̩ ʅ] ‘star’, [tʃʰyn ʅ] ‘skirt’, [tʃʰun̩ ʅ] ‘worm’, [pʰən ʅ] ‘pot’, [ʃən̩ ʅ] ‘string’, [kan ʅ] ‘pole’, and [kaŋ ʅ] ‘jar’. And, the test monosyllables which contain a sequence of ‘diphthong+nasal’ include [tʃien ʅ] ‘point’, [liən̩ ʅ] ‘beam’, [tʃʰyen ʅ] ‘circle’, [ɕiuŋ ʅ] ‘bear’, [xuən̩ ʅ] ‘soul’, [tʃʰuan ʅ] ‘boat’, and [kʰuaŋ ʅ] ‘basket’.

The speech data were provided by three native BM speakers, 1 male and 2 female, all in their early twenties. All the speakers were born and grew up in Beijing, and they were the students at the universities in Hong Kong when they took part in the study. They were asked to read the randomized test monosyllables in the wordlists at a normal rate of speech.

To obtain the articulatory data, the AG100 EMA (Electromagnetic Articulography) of Germany was used. Three sensors were pasted on the tip, anterodorsum, and posterodorsum of the tongue of the speakers for recording the location and movement of the tongue during articulation. To obtain the acoustical data, the digitally recorded speech data were analyzed for the LPC formant histories of the rimes in the test syllables, using the speech analysis software CSL (Computerized Speech Lab) 4300B by Kay Elemetrics of USA. In addition, the PC-Quirer multi-channel data acquisition system by Scicon Research and Development was used for obtaining the synchronized oral and nasal airflows for the rimes of the test syllables. The oral and nasal airflow data were used to determine the retention or deletion of a nasal ending and the nasalization of the rimes. During recording, the speakers wore the oral and nasal masks. The signals of the oral and nasal airflows were concurrently transferred from the two masks to the computer for analysis.

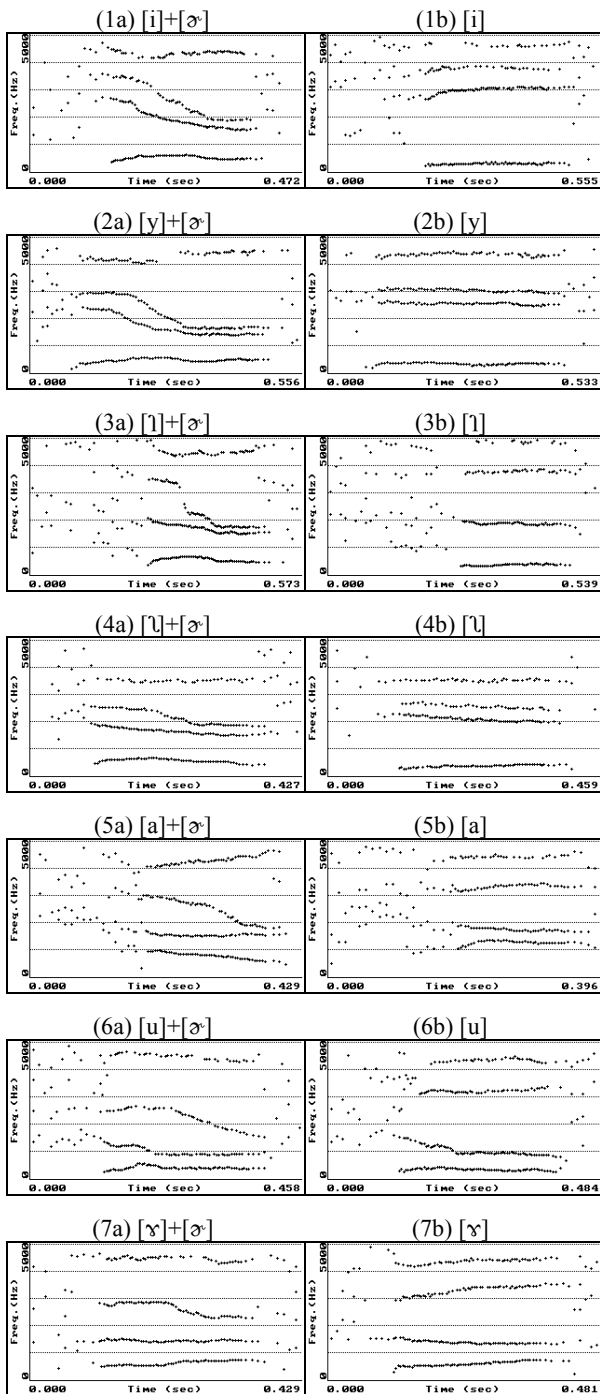
3. Results

The articulatory, acoustical, and physiological data obtained in this study show that the changes of the rimes after [ə]-suffixation vary, depending on the type of segments contained in the rimes. A common attribute for all the [ə]-suffixed rimes is the lowering of the F₃ value. F₃ is particularly low at the end portion of the [ə]-suffixed rimes. F₁ and F₂ of some [ə]-suffixed rimes also change their values. The changes of the different types of rimes after [ə]-suffixation are presented as follows. Due to the page limit, only the data from one of the three speakers are given here.

3.1. Rimes containing a monophthong

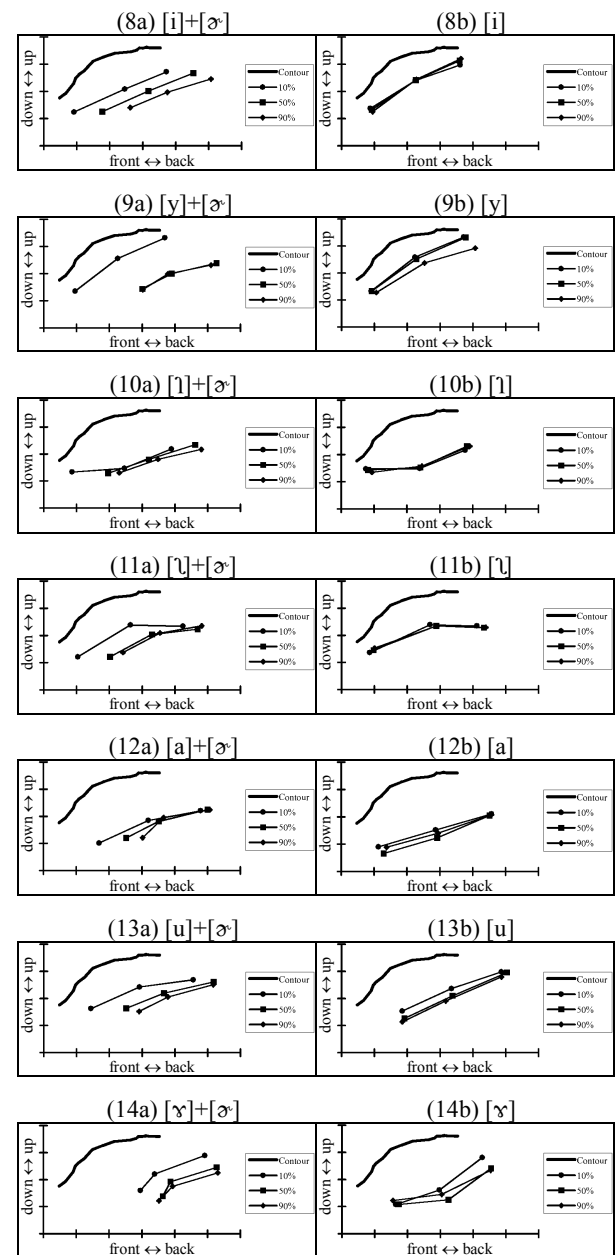
Figures 1a-b to 7a-b show the formant histories of the monophthongs [i, y, ɨ, ʌ, a, u, ʏ] with and without [ə]-suffixation for a female speaker. As can be seen, for the monophthongs with [ə]-suffixation, F₃ drops markedly toward the end of the monophthongs. The lowering of F₃ indicates that the [ə]-suffixed monophthongs become rhotacized, as rhotacization is correlated with a lowering of F₃ ([3]), though the lowering of F₃ may also be an acoustic characteristic of retroflexion ([3, 4]).

Figures 1a-b to 7a-b: Formant histories of the monophthongs with and without [ə]-suffixation (a female speaker)



According to the articulatory data in this study, the [ə]-suffixed monophthongs in BM are not retroflexed. Figures 8a-b to 14a-b show the articulatory data of the positions of the tip, anterodorsum, and posterodorsum of the tongue at the 10%, 50%, and 90% (joined by a line connecting the dots), 50% (joined by a line connecting the squares), and 90% (joined by a line connecting the diamonds) of the total duration of the monophthongs [i, y, ɨ, ʌ, a, u, ʏ] for the same female speaker. The mid-sagittal contour (the thick line) starting from the back of the upper frontal teeth to the hard palate of the speaker is also shown in the figures, which is used as the fixed reference relative to which the positions of the tongue are compared. All the figures are drawn with the same scale, where one grid on the x-axis or y-axis represents 10 mm.

Figures 8a-b to 14a-b: Positions of the tip, anterodorsum, and posterodorsum of the tongue at the 10%, 50%, and 90% of the total duration of the monophthongs with and without [ə]-suffixation (a female speaker)



As shown in Figures 8a-14a, the tip of the tongue does not raise or curl up for the [ɤ]-suffixed monophthongs, indicating that the monophthongs are not retroflexed as described in Chao's studies ([1, 2]). The articulatory data in this study also show that pharyngealization occurs in the production of the [ɤ]-suffixed monophthongs in BM. A comparison of the tongue positions for the monophthongs with and without [ɤ]-suffixation in Figures 8a-b to 14a-b shows that for the [ɤ]-suffixed monophthongs the tongue moves backward passing the hard palate toward the pharynx. The pharyngealization of the [ɤ]-suffixed monophthongs further supports the rhotacization caused by the [ɤ]-suffixation, as rhotacization is generally assumed to be accompanied by pharyngealization ([3, 5]).

The [ɤ]-suffixation also causes the tongue to change its vertical and horizontal positions, resulting in a change in F_1 and F_2 . As shown in Figures 1a-b to 5a-b, the F_1 and F_2 of the [ɤ]-suffixed monophthongs, including the front vowels [i, y], the apical anterior and posterior vowels [ɿ, ʅ], and the low vowel [a], are changing continuously, indicating that [i, y, ɿ, ʅ, a] have become diphthongized. In general, the formant pattern for the initial portion of the [ɤ]-suffixed [i, y, ɿ, ʅ, a] is similar to the formant pattern for the corresponding plain [i, y, ɿ, ʅ, a]. However, the formant pattern for the end portion of the [ɤ]-suffixed [i, y, ɿ, ʅ, a] differs from that for the plain [i, y, ɿ, ʅ, a] considerably. Articulatorily, for the [ɤ]-suffixed [i, y], the tongue moves backward and slightly downward after the 10% of the total duration of the vowels (Figures 8a-9a). The movement is paralleled by a large decrease in F_2 and a small increase in F_1 for the [ɤ]-suffixed [i, y] (Figures 1a-2a). These articulatory and acoustical data indicate that toward the end portion of the [ɤ]-suffixed [i, y], [i, y] become [ɤ]. Similar change is also found in the [ɤ]-suffixed [ɿ, ʅ, a], where [ɿ, ʅ, a] become [ɤ] toward the end portion of the monophthongs (Figures 3a-5a and 10a-12a). Thus, the non-back monophthongs [i, y, ɿ, ʅ, a] become [iɤ, yɤ, ɿɤ, ʅɤ, aɤ] after [ɤ]-suffixation.

As for the [ɤ]-suffixed back monophthongs [u, ʊ], the formant histories of F_1 and F_2 are similar to those for the plain [u, ʊ] (Figures 6a-b to 7a-b). However, there is a large decrease in F_3 for the [ɤ]-suffixed [u, ʊ], especially toward the end of the monophthongs. As for the articulatory data of [u, ʊ] (Figures 13a-b and 14a-b), the tongue moves further backward after [ɤ]-suffixation. Since the backward movement of the tongue introduces a decrease in F_3 and has no considerable effect on F_1 and F_2 , it is considered that no [ɤ] is added to the [ɤ]-suffixed [u, ʊ] and the monophthongs simply become rhotacized, i.e., [uɣ, ʊɣ].

3.2. Rimes containing a diphthong or triphthong

Due to the space limit, the articulatory and acoustic data of the [ɤ]-suffixed diphthongs and triphthongs are not presented here. Based on the experimental data obtained in this study, the changes for the diphthongs and triphthongs in BM after [ɤ]-suffixation are described as follows.

In general, the diphthongs [ie, ye, ai, ei, ia, ua, au, ou, uo] and triphthongs [uai, uei, iau, iou] are suffixed with [ɤ] or become rhotacized after [ɤ]-suffixation, depending on the type of the final vowel element of the diphthongs or triphthongs.

In the cases of the [ɤ]-suffixed diphthongs [ie, ye, ai], the final vowel element [e] or [i] of the diphthongs is deleted and substituted with [ɤ]. Thus, [ie, ye, ai] become [iɤ, yɤ, aɤ] after [ɤ]-suffixation. For the [ɤ]-suffixed [ei], the final vowel element [i] is also deleted and replaced with [ɤ]. In addition, the first vowel element [e] becomes a central vowel [ə]. Thus, [ei] becomes [əɤ] after [ɤ]-suffixation.

As for the [ɤ]-suffixed [ia, ua], the two vowel elements of the diphthongs are retained, but the second vowel element [a] of the diphthongs becomes rhotacized and there is a [ɤ] added after [a]. Thus, [ia, ua] become [iaɤ, uaɤ] after [ɤ]-suffixation.

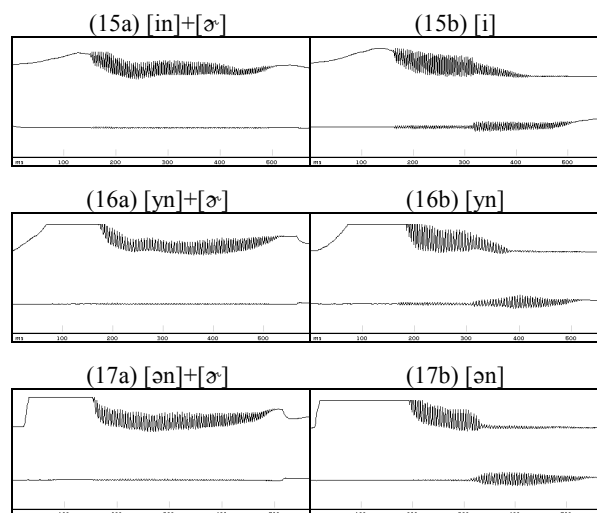
In the cases of the [ɤ]-suffixed [au, ou, uo], no [ɤ] is added to them. The two vowel elements of these diphthongs are retained, while the second vowel element [u] or [o] of the diphthongs becomes rhotacized. Thus, [au, ou, uo] become [aɣ, oɣ, uoɣ] after [ɤ]-suffixation.

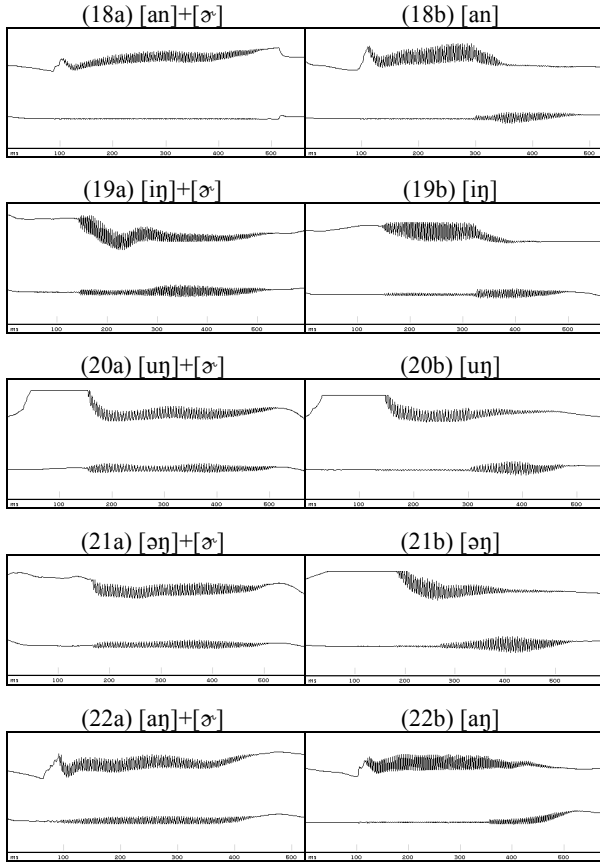
As for the triphthongs, the final vowel element [i] of both [uai] and [uei] is deleted and replaced with [ɤ] after [ɤ]-suffixation. In addition, the second vowel element of the [ɤ]-suffixed [uai] becomes rhotacized, whereas the second vowel element of the [ɤ]-suffixed [uei] becomes a central vowel [ə]. Thus, [uai, uei] becomes [uaɤ, uəɤ] after [ɤ]-suffixation. As for the [ɤ]-suffixed [iau, iou], the final vowel element [u] of the triphthongs is retained and no [ɤ] is added to the triphthongs. But, the second and third vowel elements of the triphthongs become rhotacized. Thus, [iau, iou] become [iaɣ, ioɣ] after [ɤ]-suffixation.

3.3. Rimes containing a sequence of 'vowel+nasal'

For the [ɤ]-suffixed rimes containing a sequence of 'vowel+nasal', i.e., [in, yn, ən, an, iŋ, yŋ, əŋ, aŋ], the formant and articulatory data (not presented here) show that the rimes are also suffixed with [ɤ] or become rhotacized, depending on the vowel element contained in the rimes. Besides, for the [ɤ]-suffixed [in, yn, ən, an], the alveolar nasal ending [n] is deleted. The velar nasal ending [ŋ] of the [ɤ]-suffixed [iŋ, yŋ, əŋ, aŋ] is also deleted, but the nasality is retained and passed on to the preceding vowel causing the vowel to become nasalized. Figures 15a-b to 22a-b show the oral and nasal airflows of the rimes [in, yn, ən, an, iŋ, yŋ, əŋ, aŋ] with or without [ɤ]-suffixation for the female speaker. As can be seen, for the plain [in, yn, ən, an] (Figures 15b-18b), the nasal airflow starts or starts to increase near the point where the oral airflow begins to decrease. Furthermore, the oral airflow ends before the nasal airflow does. These airflow data indicate that the vowel of the plain [in, yn, ən, an] is partially nasalized and the nasal ending is intact. As for the [ɤ]-suffixed [in, yn, ən, an] (Figures 15a-18a), while the oral airflow is visible, the nasal airflow does not show. This indicates that the nasal ending [n] of the [ɤ]-suffixed [in, yn, ən, an] is deleted and the vowel of the rimes is not nasalized. According to the articulatory and formant data of the [ɤ]-suffixed [in, yn, ən, an] (not presented here), the nasal ending [n] is replaced with [ɤ]. Thus, [in, yn, ən, an] become [iɤ, yɤ, əɤ, aɤ] after [ɤ]-suffixation.

Figures 15a-b to 22a-b: Oral (upper) and nasal (lower) airflows for the rimes containing a sequence of 'vowel+nasal' with and without [ɤ]-suffixation (a female speaker)





As for the plain [iŋ, uŋ, əŋ, aŋ] that contain a velar nasal ending [ŋ] (Figures 19b-22b), the oral airflow also ends before the nasal airflow does, and the nasal airflow starts to increase near the point where the oral airflow begins to decrease. This indicates that the vowel of [iŋ, uŋ, əŋ, aŋ] is nasalized and the nasal ending is intact. But, when [iŋ, uŋ, əŋ, aŋ] are [ɤ]-suffixed (Figures 19a-22a), both of the oral and nasal airflows of the rimes start and end almost simultaneously, indicating the whole of the rimes becomes nasalized and the nasal ending [ŋ] is deleted. The articulatory and formant data of the [ɤ]-suffixed [iŋ, əŋ, aŋ, uŋ] (not presented here) confirm that the nasal ending [ŋ] is deleted. In addition, for the [ɤ]-suffixed [iŋ, əŋ, aŋ], the final nasal is substituted with [ɤ]. Thus, [iŋ, əŋ, aŋ] become [iɤ̃, əɤ̃, aɤ̃] after [ɤ]-suffixation. As for the [ɤ]-suffixed [uŋ], no [ɤ] is added to the rime and the rime becomes rhotacized. So, [uŋ] becomes [ũ̃] after [ɤ]-suffixation.

3.4. Rimes containing a sequence of ‘diphthong+nasal’

For the rimes that contain a sequence of ‘diphthong+nasal’, i.e., [ien, yen, uən, uan, ian, uan, iuŋ], the changes of the diphthong in the rimes resulted from [ɤ]-suffixation are in general similar to those of the [ɤ]-suffixed rimes that contain a single diphthong. But, for the ‘diphthong+nasal’ rimes, the two vowel elements of the diphthong are retained, which is not always the case for the rimes that contain a single diphthong. The changes of the rimes that contain ‘diphthong+nasal’ depend on the type of the elements of the rimes. Based on the formant, articulatory, and oral-nasal airflow data of the [ɤ]-suffixed [ien, yen, uən, uan] (not presented here), the nasal ending [n] is deleted and replaced with [ɤ]. In addition, the final vowel element [e] of the diphthongs in [ien, yen] becomes a central vowel [ə], and the final vowel element [a] of the diphthong in [ian] becomes rhotacized. Thus, [ien, yen, uən, uan] become [iəɤ̃, yəɤ̃, uəɤ̃, uaɤ̃] after [ɤ]-suffixation.

As for the [ɤ]-suffixed [ian, uan, iuŋ], the formant, articulatory, and oral-nasal airflow data (not presented here) show that the nasal ending [ŋ] is deleted, but its nasality is retained and passed on to the preceding rime causing the rime to become nasalized. Besides, for the [ɤ]-suffixed [ian, uan], the rimes are added with [ɤ] and the second vowel element [a] of the diphthong in the rimes becomes rhotacized. Thus, [ian, uan] become [iãɤ̃, uãɤ̃] after [ɤ]-suffixation. As for the [ɤ]-suffixed [iuŋ], no [ɤ] is added to the rime, and the second vowel element [u] of the diphthong in the rime becomes rhotacized. Thus, [iuŋ] becomes [iũ̃] after [ɤ]-suffixation.

4. Conclusions

In BM, the [ɤ]-suffixation is a common morphological process, where the diminutive morpheme “er” [ɤ] ‘child’ is suffixed to a monosyllable. A variety of change of the rimes occurs as a result of [ɤ]-suffixation. The changes, including vowel rhotacization, vowel centralization, vowel deletion, vowel nasalization, and nasal deletion, are determined by the type of vowel or nasal ending of the rimes. All the changes that occur in the language have been described in this paper, and the articulatory, acoustical, and oral-nasal airflow data have been presented in support of the statements about these changes. The changes are summarized in Table 1. After [ɤ]-suffixation, some of the rimes have merged, constituting a case of phonological neutralization. Furthermore, two types of [ɤ]-suffixed rimes are formed, oral and nasalized.

Table 1: Changes of the rimes after [ɤ]-suffixation in BM

Plain rimes		Oral [ɤ]-suffixed rimes		Plain rimes		Nasalized [ɤ]-suffixed rimes
[i, ie, in]	→	[iɤ̃]		[iŋ]	→	[iũ̃]
[ien]	→	[iəɤ̃]				
[y, ye, yn]	→	[yɤ̃]				
[yen]	→	[yəɤ̃]				
[ɿ]	→	[ɿɤ̃]				
[ʅ]	→	[ʅɤ̃]				
[a, ai, an]	→	[aɤ̃]		[aŋ]	→	[ãɤ̃]
[ɑ]	→	[ɑɤ̃]				
[u]	→	[u]		[uŋ]	→	[ũ̃]
[ei, ən]	→	[əɤ̃]		[əŋ]	→	[əũ̃]
[ia]	→	[iãɤ̃]		[ian]	→	[iãũ̃]
[ua, uan, uai]	→	[uaɤ̃]		[uan]	→	[uãũ̃]
[au]	→	[au]				
[ou]	→	[ou]				
[uo]	→	[uo]				
[uən, uei]	→	[uəɤ̃]				
				[iuŋ]	→	[iũ̃]
[iau]	→	[iãu]				
[iou]	→	[iõu]				

5. References

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