

Classification and interpretation of tone sandhi in three-tone Jiaoliao Mandarin

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Abstract: Jiaoliao Mandarin is one of the dialects of Mandarin Chinese that coexists with three-tone and four-tone systems. The three-tone system was created by combining the main four traditional tone classes of Mandarin Chinese. This study focuses on the representative points of the three-tone dialect in Jiaoliao Mandarin and analyzes three categories of tone sandhi in the three-tone system. Additionally, the investigation suggests that these three categories reflect the different time stages of tone formation and development in the three-tone system.

Keywords: Jiaoliao Mandarin, three-tone system, four-tone system, tone sandhi, the categories of tone sandhi

1. Introduction

Jiaoliao Mandarin Chinese is primarily spoken in the Jiaodong Peninsula of Shandong Province and the Liaodong Peninsula of Liaoning Province (*Atlas of Chinese Languages (2nd Edition): Volume on Chinese Dialects*, 2012: B-14). Jiaoliao Mandarin in the Liaodong Peninsula originated from the Jiaodong Peninsula (Zhang, 2007; Luo, 2010), as shown in Figure 1.¹

The Jiaoliao Mandarin dialects have between four (the mainstream) to three tones, with each of its subdialects (Qinglai, Denglian, and Gaihuan) having its three-tone varieties. Jiaoliao Mandarin has been shifting from a four-tone to a three-tone system in recent decades, and it is interesting to investigate the time when the three-tone dialects were created.

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¹ The language mapping software developed by Nankai University and Tianjin Xinhui Network Technology Service Center is used in all the language maps listed in this paper; the base map is based on Gaode map (©2023AutoNavi—GS (2022)1061).

Based on the investigations of Qian (2001), Zhang (2000), Gao and Sun (2021), Liu (2021), and this article, the distribution of three-tone dialect points in Jiaoliao Mandarin is shown in Figure 2.



Figure 1: The distribution of Jiaoliao Mandarin.

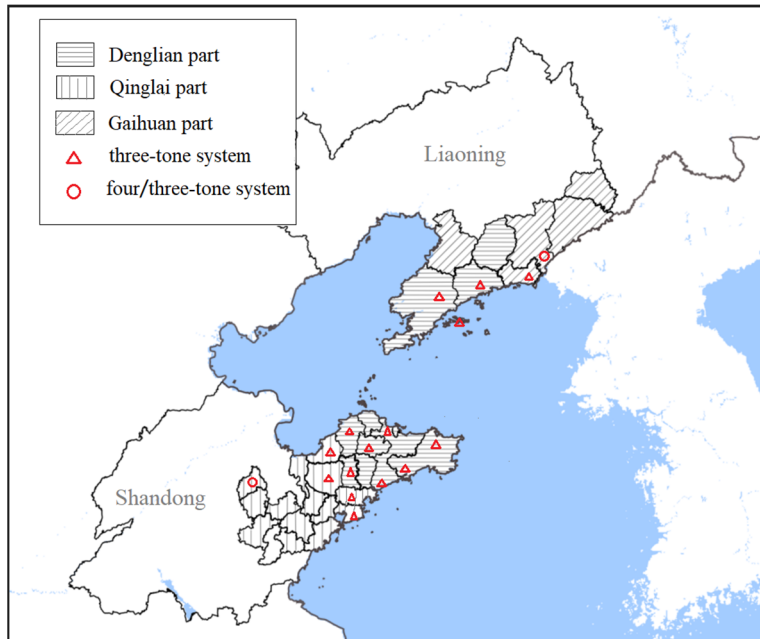


Figure 2: Jiaoliao classification and the number of tones.

2. The single-character tones and compound-character tones of the representative points of dialects in Jiaoliao Mandarin

According to Li (2004), there are two categories of disyllabic tones "tone changes due to phonetic variation" and "tone changes due to semantic variation (including neutral tones, and so on).

There is a difference between coarticulation and tone sandhi in disyllabic tones. The main difference between these two categories is that the tone sandhi can be recognized by the human ear, can traverse tonal categories, and is a manifestation of language peculiarity. Coarticulation often can not be recognized by the human ear due to physiological mechanisms of pronunciation and is universal to all languages (Wang, 2002).

Chinese has a dominant number of disyllabic words, which is the core domain of tone sandhi. This study focuses on the tone sandhi of disyllabic words in the representative dialects of Jiaoliao Mandarin, including Qingzhou, Qingdao, Laizhou, Yantai, Dalian, and Dandong.

2.1. Qingzhou dialect

2.1.1 Qingzhou urban dialect

The urban dialect of Qingzhou uses a four-tone system. Table 1 displays the tonal variations for the single-character tones and combined character tones (the boxed tone values in the table represent tone sandhi, the same applies to subsequent cases).

Table 1: Tones of the urban dialect of Qingzhou.

Citation tones	Disyllabic tones	
	Tone sandhi without neutral tone	Tone sandhi with neutral tone
①213 ②42 ③55 ④21 (Qian, 2001:100)	213+213→ 24 +213 55+213→ 24 +213 55+42→ 435 +42 55+55→ 42 +55	(No record)
①213 ②53 ③55 ④41 (Liu, 2021)	213+213→ 35 +213 airplane 飞机 53+41→ 45 +31 farm tools 农具 55+53→ 435 +54 emotion 感情 55+55→ 43 +45 factory manager 厂长	①+0→ 31 11 knife 刀子 ②+0→ 35 44 bug 虫子 ③+0→ 213 44 plank 板子 ④+0→ 45 21 trousers 裤子

Note: ①Yin; ②Yang; ③Shang; ④Qu; "0" refers to a neutral tone.

Although the two articles of Qian (200) and Liu (2021) were written twenty years apart, the patterns of single-character tones and the rules for tone sandhi in combined characters are largely comparable.

2.1.2 Qiujiayu dialect of Qingzhou (four/three-tone system)

Liu (2021) reported that there are differences in tone types amongst various age groups in Qiujiayu Village, which is located in the southwest of Qingzhou City. The single-character tones and combined-character tones of the Qiujiayu dialect for each age group are shown in Table 2.

Table 2: Tone variations in the Qiujiayu dialect of Qingzhou according to age.

	Citation tones	Disyllabic tones	
		Tone sandhi without neutral tone	Tone sandhi with neutral tone
Elderly group	①214 ②53 ③55 ④31	214+214→ $\overline{55}$ +214 airplane 飞机 55+55→ $\overline{54}$ +55 factory manager 厂长	
Middle-aged group	① 214 ② 54/55 ③55 ④31	214+214→ $\overline{55}$ +214 airplane 飞机 55+55→ $\overline{54}$ +55 factory manager 厂长	①+0→ $\overline{31}$ + $\overline{22}$ ideas 心思 ②+0→ $\overline{24}$ + $\overline{54}$ mustache 胡子 ③+0→ $\overline{213}$ + $\overline{44}$ plank 板子
Young group	① 214 ② ③ 55 ④31	214+214→ $\overline{55}$ +214 airplane 飞机 55+55→ $\overline{54}$ +55 the end of the year 年底 55+55→ $\overline{44}$ +55 factory manager 厂长	④+0→ $\overline{55}$ + $\overline{31}$ case 案子

Table 2 demonstrates that:

- (1) Citation tones are in the transitional period from the four-tone to the three-tone system;
- (2) The reason for merging ②Yang into ③Shang is that their pitch values are similar;
- (3) There is a distinct difference in tonal categories on the syllable before the neutral tone regardless of whether the system is four or three tones, in all age groups.

2.2 Laizhou dialect

The Laizhou dialect is classified under the Qinglai subdialects of Jiaoliao Mandarin, and its tone system belongs to the three-tone type (the Qu tone merging with the Yang tone)². The single-character tones and combined-character tones of the Laizhou dialect are shown in Table 3.

² In the Laizhou dialect, a small portion of the Qu tone characters are pronounced as Yin tone, which is mainly a result of language contact. Laizhou is closely adjacent to the Donglai dialect

Table 3: Tones of the Laizhou dialect.

Citation tones	Disyllabic tones	
	Tone sandhi without neutral tone	Tone sandhi with neutral tone
①213 ②④42 ③55 (Qian, Ota 2005:6)	213+213→ $\overline{45}$ +213 cold 伤风	①+0→213+ $\overline{42}$ clothes 衣裳
	42+42→ $\overline{213}$ +42 brown sugar 红糖	①+0→ $\overline{42}$ + $\overline{2}$ lively 热闹
	42+55→ $\overline{213}$ +55 first 第一	②+0→ $\overline{55}$ + $\overline{3}$ stone 石头
	55+42→ $\overline{213}$ +42 buffalo 水牛	④+0→42+ $\overline{2}$ uncle 大爷
	55+55→ $\overline{213}$ +55 watches 手表	③+0→ $\overline{45}$ + $\overline{3}$ ear 耳朵
	55+55→ $\overline{42}$ +55 lotus root starch 藕粉	③+0→ $\overline{42}$ + $\overline{2}$ dress up 打扮
①323 ②④51 ③44 (Yang, 2012)	323+323→ $\overline{44}$ +323 airplane 飞机	①+0→323+ $\overline{43}$ brick 砖头
	51+51→ $\overline{323}$ +51 wool 羊毛	①+0→ $\overline{51}$ + $\overline{21}$ date 日子
	51+55→ $\overline{323}$ +44 government 政府	②+0→ $\overline{44}$ + $\overline{31}$ stone 石头
	55+55→ $\overline{323}$ +44 entertain guests 请客	④+0→51+ $\overline{21}$ can 罐头
	55+55→ $\overline{51}$ +44 factory manager 厂长	③+0→ $\overline{34}$ + $\overline{21}$ inside 里头

Table 3 indicates that:

- (1) For more than a decade, the Laizhou dialect's citation tone pattern and tone sandhi rules have stayed constant;
- (2) There is a distinct difference between merged Yang and Qu tones before the neutral tone;
- (3) The original ④Qu tone (now pronounced as Yang and Yin) has the same pronunciation as the neutral tone, and its pitch value reflects the original feature falling.

2.3 Qingdao dialect

The Qingdao dialect is classified under the Qinglai subdialects of Jiaoliao Mandarin, and its tone system belongs to the three-tone type (the Qu tone merging with the Yang tone). The single-character tones and combined-character tones of the Qingdao dialect are shown in Table 4.

of Shandong, where approximately 42% of the Middle Chinese voiced sonorant characters in the three-tone dialect are pronounced as Yin tone, while the rest are pronounced as Qu tone (see Yang 2012 for more details).

Table 4: The tones of the Qingdao dialect.

Citation tones	Disyllabic tones	
	Tone sandhi without neutral tone	Tone sandhi with neutral tone
①213 ②④42 ③55 (Li, 1999:9-11)	213+213→ $\boxed{55}$ +213 airplane 飞机 42+42→ $\boxed{31}$ +42 moneygrubber 财迷 be bullied 受气 42+55→ $\boxed{31}$ +55 Tuan island 团岛 diving 跳水 55+55→ $\boxed{31}$ +55 island 海岛	①+0→ $\boxed{31}$ + $\boxed{2}$ knife 刀子 ②+0→ $\boxed{55}$ + $\boxed{4}$ pliers 钳子 ④+0→42+ $\boxed{2}$ wood 木头 ③+0→55+ $\boxed{4}$ dress up 打扮 ③+0→ $\boxed{45}$ +5 deal 买卖
①213 ②④42 ③55 (Qian, 2001:91, 98, 109)	213+213→ $\boxed{55}$ +213 42+42→ $\boxed{31}$ +42 42+55→ $\boxed{31}$ +55 55+55→ $\boxed{31}$ +55	①+0→ $\boxed{31}$ + $\boxed{1}$ ②+0→ $\boxed{55}$ + $\boxed{1}$ ④+0→42+ $\boxed{1}$ ③+0→55+ $\boxed{1}$ ③+0→ $\boxed{434}$ + $\boxed{1}$

Table 4 reveals that:

(1) There is a distinct difference between merged ②Yang and ④Qu tones before the neutral tone;

(2) The original ④Qu tone reflects the original falling feature before the neutral tone.

2.4 Yantai dialect

The Yantai dialect is classified under the Denglian subdialects of Jiaoliao Mandarin, and its tone system belongs to the three-tone type (the Yang tone merging with the Qu tone). The single-character tones and combined-character tones of the Yantai dialect are shown in Table 5.

Table 5: The tones of the Yantai dialect.

Citation tones	Disyllabic tones	
	Tone sandhi without neutral tone	Tone sandhi with neutral tone
①31 ③214 ②④去 55 (Qian, 1982:15, 66-80)	31+31→ $\boxed{35}$ +31 hillside 山坡 214+31→ $\boxed{35}$ +31 palm 手心 214+214→ $\boxed{55}$ +214 wheat 小麦 55+55→ $\boxed{31}$ +55 bark 树皮 labour 劳力	①+0→31+ $\boxed{21}$ box 箱子 ③+0→214+ $\boxed{55}$ tail 尾巴 ②+0→55+ $\boxed{21}$ snake 长虫 ④+0→55+ $\boxed{21}$ joke 笑话 occasionally: ③+0→ $\boxed{55}$ + $\boxed{31}$ dimple 酒窝

①31 ③214 ②④去 55 (Qian, 2001:91, 95, 108)	$31+31 \rightarrow \boxed{35}+31$ $214+31 \rightarrow \boxed{35}+31$ $214+214 \rightarrow \boxed{55}+214$ $55+55 \rightarrow \boxed{31}+55$	$\textcircled{1}+0 \rightarrow 31+\textcircled{21}$ $\textcircled{3}+\text{轻} \rightarrow 214+\boxed{55}$ $\textcircled{2}\textcircled{4}+0 \rightarrow 55+\boxed{31}$ $\textcircled{3}+0 \rightarrow \boxed{55}+31$ (occasionally)
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Data in Table 5 show that in Yantai dialect, the original ②Yang and ④Qu citation tones have merged, and there is no difference between them before the neutral tone (they are both high-level tones), which is different from Laizhou and Qingdao dialects.

2.5 Dalian dialect

The Dalian dialect is classified under the Denglian subdialects of Jiaoliao Mandarin, and the internal single-syllable tones of the Dalian dialect vary between the four-tone and three-tone systems. Song (1963) reported that the four-tone types in the urban area of Dalian are "Yin 312, Yang 34, Shang 213, and Qu 53", while in the Zhuanghe area of Dalian, the three-tone types are "Yin 312, Shang 213, and Qu (including Yang) 53".

2.5.1 Dalian urban dialect

According to historical survey records, the urban dialect of Dalian belongs to the four-tone system³. The single-character tones and compound-character tones of the Dalian urban dialect are shown in Table 6.

Table 6: The tones of the Dalian urban dialect.

Citation tones	Disyllabic tones	
	Tone sandhi without neutral tone	Tone sandhi with neutral tone
①312 ②34 ③213 ④53 (Song, 1963)	(No record)	(No record)
①312 ②34 ③213 ④53 (Li, 1996:733-735)	$312+312 \rightarrow 13+22$ Jinzhou 金州 $213+312 \rightarrow 13+22$ Jinzhou 锦州 $34+312 \rightarrow 34+22$ $53+312 \rightarrow 53+22$	(No record)

³ Recently, it was found that there is also a three-tone system phenomenon in Dalian urban dialect (Liu 2023), which is not listed because the relevant investigation materials have not been officially published.

①312 ②35 ③213 ④53 (Dong, 2008:67-68)	312+312→13+312 drive 开车	①+0→312+□ doctor 医生 ②+0→35+□ knowledge 良心 ③+0→213+□ shoulder pole 扁担 ④+0→53+□ honesty and kind 厚道
	312+35→31+35 arrange 安排	
	312+213→31+213 peak 山顶	
	312+53→31+53 cook 烧饭	
	213+312→13+312 Mars 火星	
	213+312→21+35 thunder 打雷	
	213+213→13+213 fruits 水果	
	213+53→21+53 vegetation 草木	

Table 6 demonstrates that the citation tones of the Dalian urban dialect only have slight coarticulation and no tone sandhi.

2.5.2 Zhuanghe dialect of Dalian

The Yang tone and Qu tone have been combined to create the Zhuanghe dialect of Dalian, which uses the three-tone system. Some are pronounced as Yin tone (e.g., “鹅 goose”), while others are merged into the Qu tone (e.g., “麻 flax”). The pronunciation of the Middle Chinese voiced sonorant characters varies, and they are irregularly allocated to the Yin, Yang, and Qu tones. This phenomenon is quite common in the Denglian subdialects of Jiaoliao Mandarin.

Table 7: Tones of the Dalian Zhuanghe dialect.

Citation tones	Disyllabic tones	
	Tone sandhi without neutral tone	Tone sandhi with neutral tone
①312 ③213 ②④53 (Song, 1963)	(No record)	(No record)
①312 ③213 ②④53 (Dong, 2008:68-69)	312+312→13+312 sidehill 山边 312+213→31+213 hard 辛苦 312+53→31+53 high-rise 高楼 Peking Opera 京剧 213+312→13+312 Beijing 北京 213+213→13+213 seawater 海水 213+53→21+53 sprinkle 小雨	①+0→312+□ watermelon 西瓜 ③+0→213+□ eight 八个 ②④+0→53+□ nice and coo 凉快 nephew 外甥

Table 7 reveals that in the Dalian Zhuanghe dialect, both citation tones and disyllabic tones are three-tone types, and there is no tone sandhi.

2.6 Dandong dialect

The Dandong dialect is classified under the Gaihuan subdialects of Jiaoliao Mandarin, and there are distinct differences in its internal single-syllable tones between the four-tone and three-tone systems. Song (1963) reported that the four-tone types in the urban area of Dandong are "Yin 312, Yang 34, Shang 213, Qu 53", while in the Donggang (Dong'an) area of Dandong, the three-tone types are "Yin 312, Shang 213, Qu (including Yang) 53".

2.6.1 Dandong urban dialect (four/three-tone system)

A survey on the urban dialect of Dandong was carried out in August 2021. Mr. Sun, 66 years old, and Ms. He, 62 years old, who are both retired employees and have completed junior high school, were the pronunciation collaborators. Both of the collaborators believe that their speech is the same. However, Mr. Sun pronounces single-syllable tones in the four-tone system, while Ms. He pronounces single-syllable tones in the three-tone system. The analysis of recorded materials using the Praat speech software produced the descriptions of the single-syllable and connected-speech tones in the Dandong dialect in this article.

Table 8: Tones of the Dandong urban dialect.

Citation tones	Disyllabic tones	
	Tone sandhi without neutral tone	Tone sandhi with neutral tone
①312 ②34 ③213 ④53 (Song, 1963)	(No record)	(No record)
①312 ②24 ③214 ④52 (Liu, 1996:691-693)	312+312→ $\boxed{35}$ +312 hometown 家乡 214+312→ $\boxed{25}$ +312 Noon 午间 214+214→ $\boxed{25}$ +214 Little Li 小李	(无记录)
①43 ②24 ③13 ④51 (Zeng, 2023)	43+43→ $\boxed{44}$ +33 cloudy sky 阴天 43+24→ $\boxed{44}$ +24 flowerpot 花盆 13+13→ $\boxed{24}$ +21 fruits 水果	①+0→ $\boxed{44}$ + $\boxed{23}$ brick 砖头 ②+0→24+ $\boxed{21}$ stone 石头 ③+0→22+ $\boxed{34}$ wharf 码头 ④+0→53+ $\boxed{21}$ can 罐头
①41 ②③13 ④52 (Zeng, 2023)	13+41→ $\boxed{24}$ +42 tomorrow 明天 13+13→ $\boxed{24}$ +23 bank 银行 13+13→ $\boxed{24}$ +21 milk 牛奶 13+52→ $\boxed{24}$ +52 culture 文化 13+41→22+42 train 火车 13+13→22+24 match 火柴 13+13→ $\boxed{24}$ +21 fruits 水果 13+52→22+52 glasses 眼镜	①+0→42+ $\boxed{23}$ brick 砖头 ②+0→24+ $\boxed{2}$ stone 石头 ③+0→22+ $\boxed{34}$ wharf 码头 ④+0→53+ $\boxed{2}$ can 罐头

From Table 8, it can be seen that:

(1) The pitch values of the ①Yin citation tone have been changed in recent decades from a low-falling tone to a high-falling tone (312 > 43/41);

(2) Tonal classifications have been simplified in recent years, such as merging ②Yang with ③Shang or ①Yin with ④Qu (Zheng, 2018; Liu, 2023);

(3) There is a noticeable division in tonal categories before the neutral tone in disyllabic tones, regardless of whether the citation tone is a four-tone or three-tone system.

2.6.2 Donggang dialect of Dandong

Local Dandong residents are aware of the linguistic difference between the Donggang dialect and the Dandong urban dialect. The Donggang dialect belongs to the three-tone system (with the merging of Yang tone and Qu tone). The specific situations of single-character tones and compound-character tones of Dandong Donggang dialect are shown in Table 9.

Table 9: Tones of the Donggang dialect of Dandong.

Citation tones	Disyllabic tones	
	Tone sandhi without neutral tone	Tone sandhi with neutral tone
①312 ③213 ②④53 (Song, 1963)	(No record)	(No record)
①51 ③213 ②④441 (Ma, 2007)	51+51→ 34 +42 airplane 飞机 213+51→ 34 +42 Mars 火星 213+21→ 34 +323 fruits 水果 441+51→ 34 +42 menu 菜单 long gown 长衫	①+轻→53+ 1 clothes 衣服 ③+轻→ 33 + 4 bone 骨头 ②④+轻→ 53 + 3 go in 进去 house 房子

Table 9 reveals that:

(1) In the Donggang dialect, the pitch value of the Yin tone has shifted from low-falling to high-falling (312 > 51) in recent decades;

(2) Both citation and disyllabic tones are three-tone types, and there is no tone sandhi.

3. From tone sandhi types to the formation and development of the three-tone system in Jiaoliao Mandarin

3.1 Types of tone sandhi within the three-tone system of Jiaoliao Mandarin

The various tone sandhi patterns in representative Jiaoliao Mandarin can be summarized and categorized as illustrated in Table 10 based on earlier citations (Tables 3-9).

Table 10: Comparison of tone sandhi categories in the Jiaoliao Mandarin three-tone dialects.

Category	Four -tone → three -tone system	The characteristics of tone sandhi		Dialects
		without neutral tone	with neutral tone	
I	Merger of ② and ④ tones	Merged tone categories that are not distinguished	Merged tone categories that are not distinguished	Yantai, Zhuanghe of Dalian, Donggang of Dandong
II	Merger of ② and ④ tones	Merged tone categories that are not distinguished	Merged tone categories that are distinguished	Laizhou, Qingdao
III	Merger of ② and ③ tones	Merged tone categories that are distinguished	Merged tone categories that are distinguished	Qiujiayu of Qingzhou, Dandong (urban area)

3.2 Timing of the three-tone Mandarin dialects formation as reflected by the different types of tone sandhi

Formation times of the three-tone Mandarin dialects in Jiaoliao are different.

For example, in the 1950s, dialects such as Yantai, Weihai, Fushan, Qixia, and Jimo in Shandong Province had become three-tone systems, while Qingdao, Haiyang, Rushan, and Zhaoyuan remained four-tone systems until the early 21st century (Qian, 2001, 2002).

Similarly, in the 1960s, Zhuanghe and Donggang in Liaoning Province were three-tone systems, while Dalian and Dandong urban areas remained four-tone systems until recent years (Song, 1963; Zeng, 2023; Liu, 2023).

Therefore, it is possible to infer the sequence of the three-tone Mandarin dialects formation in Jiaoliao through the differences in tone sandhi of the three-tone system, as shown in Table 11.

Table 11: Sequence of three-tone formation times in Jiaoliao Mandarin.

Category	I	II	III
Time of the formation	Before 1960	1960-2000	After 2000
The development stages	the stable stage	the formative stage	the initial stage
The characteristics of tone sandhi	Tone sandhi do not distinguish already merged tone categories	Tone changes before the neutral tone distinguish already merged tone categories	Tone sandhi distinguish already merged tone categories
Dialects	Yantai, Zhuanghe of Dalian, Donggang of Dandong	Laizhou, Qingdao	Qiujiayu of Qingzhou, Dandong (urban area)

3.3 The earliest region of the three-tone system formatting in Jiaoliao and its time

As depicted in Figure 3, Shandong Province's administrative boundaries under the Ming Dynasty included the majority of the Jiaodong and Liaodong Peninsulas and crossed the Bohai Strait. Therefore, at least 600 years ago, there was tight connectivity between the two peninsulas. In modern Jiaoliao variants with a three-tone system, the distribution of the three types of tone sandhi is shown in Figure 4.

The early three-tone system of Jiaoliao Mandarin (Category I) is distributed in both Shandong and Liaoning provinces (Figure 3 and Figure 4). As the Jiaoliao Mandarin in the Liaodong Peninsula came from immigrant languages in Jiaodong Peninsula, it can be considered that the Yantai dialect in Shandong is the representative variety of Jiaoliao Mandarin that first changed from a four-tone to a three-tone system.

Edkins recorded the Yantai dialect as a four-tone system in 1862: ①13, ②31, ③35, ④53 (quoted from Endo, 2015:204). Giet's recording of the Yantai dialect in 1946 had already become a three-tone system : ① a high-falling tone, ②④ a high-level tone, ③ a low-falling tone, with the merge of Tones ② and ④ (quoted from Endo, 2021). Therefore, based on that the three-tone system of the Yantai dialect was formed between 1862 and 1946, it can be assumed that the oldest instance of the transition from four to three tones in Jiaoliao Mandarin occurred no more than a century ago.



Figure 3: The area under Shandong's jurisdiction in the Ming dynasty.



Figure 4: Distribution of tone sandhi categories in the Jiaoliao Mandarin three-tone dialects.

4. Conclusion

Over the past century, some of the Jiaoliao Mandarin dialects have undergone a sound change from a four-tone to a three-tone system in monosyllabic words. This is mainly due to the merging of tonal categories with similar pitch values, and the fundamental reason is the polysyllabification of the lexicon (Qi, 2010; Wei & Zhu, 2021). The major findings of this study can be concluded as follows.

(1) There are three types of tone sandhi in disyllabic words of the Jiaoliao Mandarin dialect with a three-tone system:

Category I—Tone sandhi do not distinguish merged tone categories;

Category II—Only the pre-neutral tone sandhi distinguishes merged tone categories;

Category III—Normal disyllabic and pre-neutral tone sandhi distinguish merged tone categories.

(2) The formation time of the Jiaoliao Mandarin dialect with a three-tone system can be inferred from early to late based on these three types of tone changes: Category I > Category II > Category III.

(3) The Yantai dialect in Shandong is likely the representative of Jiaoliao Mandarin that first underwent a change from a four-tone to a three-tone system, with the three-tone system diffused from this center.

(4) Hirayama (1998) pointed out that "the values of pre-neutral tone sandhi is diachronically one step before the citation tones". However, it is unclear how much earlier pre-neutral tones actually are, and even if they are, it might not have been that long ago.

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