A SYNCHRONIC VIEW OF THE CONSONANT MUTATIONS IN FUZHOU DIALECT[1]

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Abstract. This paper investigates the consonant mutations in Fuzhou dialect. The phonological processes applied to the onset of the second syllable are conditioned by the type of the onset itself and the rime of the preceding syllable. This phenomenon poses the following two questions. First, what kind of alternations are Fuzhou consonant mutations involved and what are the triggering contexts? Second, why this phenomenon is contradicted to the universal generalization that the onset position is stronger position than the coda position? Different from the lenition analyses (Chen 1990, Dai 2010, among others), which assumes the onset undergoes a progressive assimilation, this paper proposes a synchronic analysis, which integrates the Autosegmental Theory (Wolf 2007) and the Dispersion Theory (Flemming 2004). The general idea is that Fuzhou consonant mutations are induced by the requirement of docking floating features on the onset of the second syllable, and the apparent exceptions are actually attributed the need of avoiding confusable contrasts.

Key words: consonant mutations, Autosegmental Theory, Dispersion Theory, Fuzhou dialect

1. Introduction

Consonant mutations refer to phonological processes operating in nontransparent environments, which results in various phonological alternations in the same context. For instance, Breton presents a 'quirky' mutation system (Press 1986; also see Wolf 2007). When words include the morpheme *e* 'that', *ma* 'that/if' or the progressive marker *o*, the initials will change into different phones. [b], [g] and [m] are spirantized to [v], [ɣ] and [v], respectively; [d] is devoiced to [t]; [g] in [gw] is deleted; other initials do not change.

Generally, consonant mutations can be analyzed from diachronic and synchronic points of views. On the one hand, mutations are diachronically analyzed as opaque morphological processes which are derived from transparent phonological processes (Grijzenhout 2011). On the other hand, synchronically, there are two primary approaches. First, autosegmental approaches treat mutations as docking onto segments of floating features as the realization of

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mutation-triggering morphemes (Wolf 2007). Second, anti-faithfulness approaches analyze mutations as a requirement on the distinctiveness of morphological structures.

This paper focuses on consonant mutations in Fuzhou dialect (Tao 1930; Chen and Norman 1965; Nakajima 1979; Liang 1983, 1986; Chen 1990; Feng 1993; Li, Liang, Zou and Cheng 1995; Liang and Feng 1996; Li and Feng 1998; Feng 1993; Li 2000; Chen 2010; Dai 2010).[2] Fuzhou's consonant mutations show the following properties. First, only onset consonants following other syllables (henceforth onset$_{(\sigma2)}$ consonants) undergo phonological processes, such as spirantization, nasalization, etc. Neither codas nor onsets in the first syllable have these systematic alternations. Second, the rime preceding onset$_{(\sigma2)}$ (henceforth rime$_{(\sigma1)}$) triggers phonological processes. However, the triggering context is nontransparent. For example, the onset$_{(\sigma2)}$ [s] is lateralized to [l] when the rime is V or Vʔ. It is unclear where the feature [lateral] comes from. Third, in addition to the triggering context (i.e., rime$_{(\sigma1)}$), the onset$_{(\sigma2)}$ consonant itself determines which phonological alternation is applied. For instance, when the rime$_{(\sigma1)}$ is V, the onset$_{(\sigma2)}$ [ts] mutates to [ʒ] through spirantization and palatalization but the onset$_{(\sigma2)}$ [k] is deleted.

Previous studies (Chen 1990, Dai 2010, among others) analyze consonant mutations from the diachronic perspectives. Mutations of onset$_{(\sigma2)}$ consonants are resulted from lenition, and the 'exceptions' (i.e., the mutation from [ts] to [ʒ]) are due to the historical factors. These analyses are interesting, but they are challenged by the following three arguments. First, it is well-known that onset is a strong position and coda is a weak position, so it is not plausible to assume a progressive assimilation from coda to onset. Second, Fuzhou is an iambic language based on the regressive tone sandhi and regressive vowel raising. The second syllable is prosodically stronger than the first syllable. Therefore, the analyses of lenition need to be reconsidered.

This paper aims to account for the consonant mutations in Fuzhou from a synchronic point of view, which combines the Autosegmental Theory (Wolf 2007) and the Dispersion Theory (Flemming 2004). This paper proceeds as follows. Section 2 introduces the background of Fuzhou and the consonant mutations. Then, I will review previous lenition analyses, and points out some problems they are confronted with. Section 3 proposes an autosegmental analysis that consonant mutations are resulted from docking floating features on consonants. The floating features are the phonological realization of an abstract morpheme expressing the meaning that the two adjacent morphemes have a close morphological relation. However, not all of the data (i.e., the mutation of alveolar stops and alveolar fricatives) can be well explained. Section 4 proposes that these exceptions are resulted from the need of preserving perceptual contrasts, following the Dispersion Theory (Flemming 2004). Section 5 is the conclusion.

2. Setting the stage

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[2] Previous studies call this phenomenon as 'initial assimilation' (Li 2002; Dai 2010). However, this notation may be misleading because this term cannot cover the properties I will immediately discuss. Therefore, this paper names this phenomenon as 'consonant mutations'.

2.1 Background

Fuzhou is one of representative dialects of Eastern Min dialects. In the narrow sense, Fuzhou is the dialect spoken in Fuzhou city, the eastern part of Fujian Province. In the board sense, Fuzhou refers to dialects spoken in the eleven cities or counties: Fuzhou, Pingnan, Gutian, Luoyuan, Minqing, Lianjiang, Minhou, Changle, Yongta, Fuqing and Pintan. Actually, the above areas do not have a single phonological system, and there are several phonological distinctions. In order to focus on the consonant mutations, this paper only discusses Fuzhou dialect in the narrow sense. I will leave the complicated dialectical variations for further research.

There are 13 phonemes in the consonant inventory, as (1) (Li & Feng 1998). Except for [ʔ], the consonants listed above can appear in the onset position. Besides, there are three additional possible onsets: null onset, [β] and [ʒ].[3] The latter two are allophones of [p, p^h] and [ts, ts^h], respectively. Hence, there are 15 possible consonant onsets in Fuzhou, as listed in (2).

(1) Consonant inventory

	Bilabial	Alveolar	Post-alveolar	Velar	Glottal
Stop	p^h, p	t^h, t		k^h, k	ʔ
Fricative		s			h
Affricate		ts^h, ts			
Lateral		l			
Nasal	m	n		ŋ	

(2) Possible consonant onsets: p^h, p, β, m, t^h, t, s, ts^h, ts, l, n, ʒ, k, k^h, ŋ, h, ϕ

As for rime inventory, Fuzhou contains 48 rimes (Li and Feng 1998), each of which has a "tense" form and "lax" form, as listed before and after a slash in (3), respectively.[4] These 48 rimes can be categorized into ten types, as presented by (3), where V stands for vowels and G stands for glides. The length of vowels and the distinction of vowels and glides are not important for consonant mutations discussed in this paper. In order to state the crucial patterns more clearly and discard the irrelevant factors, this paper simplifies the ten types into three types: (i) rimes without consonants (henceforth V), (ii) rimes ended by a velar nasal [ŋ] (henceforth Vŋ), and (iii) rimes ended by a glottal stop [ʔ] (henceforth Vʔ). Moreover, based on field investigations, Feng (1993) points out that some elder Fuzhou native speakers can differentiate two checked syllables: Vʔ and syllables ended by a velar stop [k] (henceforth Vk), as exemplified by (4)

[3] Previous analyses suggest that *Fuzhou* has null onsets ϕ (Tao (1930), Feng (1993), Li, Liang, Zou and Cheng (1995), Li and Feng (1998) Dai (2010)). Chen (1990) proposes that the so-called null onset is actually filled by a [ʔ]. There is no good evidence to determine which one is the better one, so I adopt the opinion most researchers agree (i.e., null onset).

[4] The lax and tense forms differ in the distribution, vowel quality, tone values and tone sandhi patterns (Li and Feng 1998). Since the distinction of these two forms is not the main concern in this paper, I will leave this issue open.

(Feng 1993: 105-111) (also see Li, Liang, Zou and Cheng 1995).[5] The two rimes indeed distinguish meanings. Besides, other diachronic analyses and cross-dialectal comparisons with other Eastern Min dialects (e.g., *Fuqing* dialect) also support that proposal that there are two checked syllables in Fuzhou. Following Feng (1993), this paper suggests that the rime inventory of Fuzhou includes four types, as listed by (5).

(3) Rime inventory (version 1)

V	a/ɑ, ɛ/ɑ, o/ɔ, œ/ɔ, i/ɛi, u/ou, y/øy	VGŋ	ɛiŋ/aiŋ, ouŋ/ɔuŋ, øyŋ/ɔyŋ,
VG	ai/ɑi, au/ɑu, ɛu/ɑu, øy/ɔy	GVŋ	iaŋ/iɑŋ, ieŋ/iɛŋ, uaŋ/uɑŋ, uoŋ/uɔŋ, yoŋ/yɔŋ
GV	ia/iɑ, ie/iɛ, ua/uɑ, uo/uɔ, yo/yɔ	Vʔ	aʔ/ɑʔ, ɛʔ, oʔ/ɔʔ, œʔ, iʔ/ɛiʔ, uʔ/ouʔ, yʔ/øyʔ
GVG	iau, ieu/iɛu, uai/uɑi, uoi/uɔi	VGʔ	ɛiʔ/aiʔ, ouʔ/ɔuʔ, øyʔ/ɔyʔ
Vŋ	aŋ/ɑŋ, ŋ̍ (n̩ m̩), iŋ/ɛiŋ, uŋ/ouŋ, yŋ/øyŋ	GVʔ	iaʔ/iɑʔ, ieʔ/iɛʔ, uaʔ/uɑʔ, uo/uɔʔ, yoʔ/yɔʔ

(4) a. piɑk[6] ☐[7] 'slap' piɑʔ 壁 'the side which nears the wall'
b. tiɛk 跌 'embarrassed' tiɛʔ 摘 'take off'
c. ts^hak 擦 'wipe' ts^haʔ 冊 'book'
d. k^hyɔk 攫 'seize' k^hyɔʔ 怯 'fear'
e. uak 挖 'dig' uaʔ ☐ 'the noise of pigs'

(5) Rime inventory (final version)
a. V b. Vŋ c. Vʔ d. Vk

With the background knowledge of the consonant and rime inventory of Fuzhou, the following section will show that whether consonant mutation take place or not and which alternations are activated depends on the type of $\text{rime}_{(\sigma1)}$.

2.2 Consonant mutations

Consonant mutation (i.e., *shengmu leihua* in Tao 1930; initial assimilation in Dai 2010) is a well-known phonological phenomenon in Eastern Min dialects. The $\text{onset}_{(\sigma2)}$ consonants undergo systematic alternations, which is conditioned by the combination of $\text{rime}_{(\sigma1)}$ and $\text{onset}_{(\sigma2)}$ (Tao 1930; Chen and Norman 1965; Nakajima 1979; Liang 1983, 1986; Chen 1990; Feng 1993; Li, Liang, Zou and Cheng 1995; Liang and Feng 1996; Li and Feng 1998; Feng 1993; Li 2000; Chen 2010; Dai 2010). This phenomenon starts from the 19th century, and become productive around 1930s (Chen 2010: 85-86).

[5] The younger generation can not perceive the contrast of [ʔ] and [k] in the coda position. Instead, the two sounds are neutralized to [ʔ].

[6] Tone markers are omitted in this paper because the tone value does not influence the consonant mutations in *Fuzhou*.

[7] ☐ means that this word does not have a correspondent Chinese character.

Generally, consonant mutations can be divided into three patterns by the type of rime$_{(\sigma1)}$. First, when the rime$_{(\sigma1)}$ is V or Vʔ, several phonological processes are applied to onset$_{(\sigma2)}$. Bilabial stops [p, p^h] are spirantized and voiced to a voiced bilabial fricative [β]. Alveolar stops [t, t^h], and alveolar fricatives [s] are voiced and lateralized into [l]. Alveolar affricates [ts, ts^h] are voiced, spirantized and palatalized to a voiced post-alveolar fricative [ʒ]. Velar stops [k, k^h] and glottal fricatives [h] are deleted. Laterals [l] and nasals [m, n, ŋ] do not undergo any change. Please see the table below for these alternations.

(6) Consonant mutations (rime $_{(\sigma1)}$: V, Vʔ)

Onset $_{(\sigma2)}$		Alternations	Examples			
p, p^h	→ [β]	voicing spirantization	V	耳扒	ŋi pa	→ ŋi βa
				土匪	t^{h}u p^{h}i	→ t^{h}u βi
			Vʔ	拍平	p^{h}aʔ paŋ	→ p^{h}aˀ βaŋ
				藥片	yoʔ p^{h}iɛŋ	→ yoˀ βiɛŋ
t, t^h, s	→ [l]	voicing lateralization	V	花店	hua taiŋ	→ hua laiŋ
				丫頭	a t^{h}au	→ a lau
				火石	huoi suoʔ	→ huoi luoʔ
			Vʔ	白撞	paʔ tɔuŋ	→ paˀ lɔuŋ,
				額頭	ŋieʔ t^{h}au	→ ŋieˀ lau
				白衫	paʔ saŋ	→ paˀ saŋ
ts, ts^h	→ [ʒ]	voicing spirantization palatalization	V	厝租	ts^{h}uo tsu	→ ts^{h}uo ʒu
				老鼠	lo ts^{h}y	→ lo ʒy
			Vʔ	落座	loʔ tsɔ	→ loˀ ʒɔ
				白菜	paʔ ts^{h}ai	→ paˀ ʒai
k, k^h, h	→ ϕ	deletion	V	豬角	ty kɔyʔ	→ ty ɔyʔ
				硋器	hai k^h-ɛi	→ hai ɛi,
				火烌	hui hu	→ hui u
			Vʔ	石囝	suoʔ kiaŋ	→ suoˀ iaŋ
				澈潔	taʔ kaiʔ	→ taˀ aiʔ
				藥粉	yoʔ huŋ	→ yoˀ uŋ
m, n, ŋ, l	→ --	no change	V	走廊 tsau louŋ, 大門 tuai muoŋ,		
				大儂 tuai nøyŋ, 發芽 puo ŋa		
			Vʔ	白鷺 paʔ lou, 虱母 sɛiʔ mo,		
				白仁 paʔ niŋ, 鯽魚 tsiʔ ŋy		

Second, all onset$_{(\sigma2)}$ consonants precede rime $_{(\sigma1)}$ Vŋ are nasalized, except for nasals [m, n, ŋ] and alveolar affricates [ts, ts^h]. Nasals do not undergo any process; alveolar affricates are spirantized and palatalized into [ʒ]. This type of consonant mutations is illustrated as (7).

(7) Consonant mutations (rime $_{(\sigma 1)}$: Vŋ)

Onset$_{(\sigma 2)}$	Alternations	Examples
p, p^h → [m]	nasalization	郎爸 louŋ pa → louŋ ma 宗派 tsuŋ p^huai → tsuŋ muai
t, t^h, s, l → [n]	nasalization	元旦 ŋuoŋ taŋ → ŋuoŋ naŋ 陰天 iŋ t^hieŋ → iŋ nieŋ 洋参 yoŋ sɛi → yoŋ nɛi 金鏈 kiŋ liɛŋ → kiŋ niɛŋ
ts, ts^h → [ʒ]	Voicing, spirantization palatalization	簽字 ts^hieŋ tsɛi → ts^hieŋ ʒɛi 青草 ts^haŋ ts^hau → ts^haŋ ʒau
k, k^h, h → [ŋ]	nasalization	龍骨 lyŋ kɔuʔ → lyŋ ŋɔuʔ 蒸氣 tsiŋ k^hɛi → tsiŋ ŋɛi 洋戲 yoŋ hiɛ → yoŋ ŋiɛ
m, n, ŋ → --	no change	東門 tøyŋ muoŋ, 換乇 uaŋ nɔʔ 上元 suoŋ ŋuoŋ

Third, no phonological change is applied on the onset$_{(\sigma 2)}$ consonants if they are preceded by the rime $_{(\sigma 1)}$ Vk, as shown by (8).

(8) Consonant mutations (rime $_{(\sigma 1)}$: Vk)

Onset $_{(\sigma 2)}$	Alternations	Examples		
all	none	踏板 tak pɛiŋ 辣椒 lak tsieu 出名 ts^houk miaŋ	鍘刀 tsak to 敓殼 kak k^hɔk 什乇 siek nɔʔ	鴨雄 ak hyŋ 夾粒 kak laʔ

Table (6-8) show that both the type of rime$_{(\sigma 1)}$ and the phone of onset$_{(\sigma 2)}$ consonant play an important role on consonant mutations.

Furthermore, whether Fuzhou consonant mutations are applied or not is also conditioned by other factors, especially the morphological structures of two adjacent phones (Liang 1983; Li 2000).[8] Simply speaking, words exhibit consonant mutations, while phrases do not have these systematic alternations. Please consider the contrast in the table (9) (Liang 1983: 167; Li 2000: 126-127). Examples in the left column are parsed as phrases, while those in the right column are parsed as words. Notice that only the latter ones undergo consonant mutations.

(9) Consonant mutations conditioned by the syntax (phrases vs. words)

	no mutation (phrase)		mutation (words)	
洗水	sɛ tsui	'wash by water'	sɛ jui	'swim'
菜頭	ts^hai tau	'the root of vegetables'	ts^hai lau	'radish'
骹手	ka ts^hiu	'legs and hands'	ka ʒiu	'staff'
大頭	tuai t^hau	'big head'	tuai ʒau	'tall'

[8] There are other pragmatic factors. The register may also affect the operation of consonant mutations. For example, mutation may be blocked in official situations, but it tends to apply in casual situations. Besides, there is also a contrast between common words and uncommon words. Consonant mutations often apply in the former case but not in the latter one.

Therefore, whether a sequence of two phones performs the phenomenon of consonant mutations is determined by the syntactic and morphological structures.

More interestingly, in some cases whether mutations apply is conditioned by the meanings of a word. Please consider the following instances (Liang 1983: 166; Li 2000: 125).

(10) Consonant mutations conditioned by meanings (original vs. extended)

	no mutation		mutation	
火把	hui pa	'torch'	hui βa	'fried dough twist'
依嫂	i so	'sister-in-law'	i lo	'housemaid
分開	puoŋ k^huoi	'separate'	puoŋ ŋuoi	'divide a large family into smaller groups'

I suggest that words which do not undergo phonological process have the original meanings as examples in the left column, while words which undergo phonological process have extended meanings as examples in the right column.[9] For instance, the original meaning of 火把 is 'torch', which is pronounced as [hui pa], while the extended meaning is 'fried dough twists', which is pronounced as [hui βa]. In Fuzhou, since torches are made by bamboo splints and Fried dough twists look like bamboo torche (Li and Feng 1998), the two meanings share the same phones. For another example, the original meaning of 依嫂 is 'sister-in-law'. The extended meaning 'housemaid' may be derived from the fact that sisters-in-law always takes good care of her families-in-law, including the housework, and are just like housemaids. Thus, the onset$_{(\sigma 2)}$ mutates in the word with the extended meaning 'housemaid', but the onset$_{(\sigma 2)}$ does not mutate in the word with the original meaning 'sister-in-law'. As the anonymous reviewer points out, since the words undergoing mutations have more meanings than those without phonological alternations, this proposal predicts that children will acquire the former ones later than the latter ones. Moreover, the original meaning of the mutated words is predicted to be acquired earlier than the extended meaning. This suggestion, though correct, is out of the scope of this paper, so I will leave it for further researches.

The properties of consonant mutation raise some interesting problems. First, consonant mutation is only applied to onset$_{(\sigma 2)}$ consonants. However, it is well-known that onset is a strong position and coda is a weak position, as discussed by numerous studies based on typological implication and perceptual cues. Fuzhou consonant mutation is contradicted to the universal generalization. Second, the type of rime$_{(\sigma 1)}$ determines the kind of the consonant mutations, as shown by (6-8). However, the rime$_{(\sigma 1)}$ (e.g., V or Vʔ) does not provide

[9] Notice that the examples, which do not undergo mutations, are also words. This may be contradictory to the generalization observed in (9). One plausible explanation is that these words were all mutated before but they stop alternating later in order to avoid the comprehension confusion between the original meaning and extended meaning. Since lexicons with extended meanings are more grammaticalized than the ones with original meanings, the former ones keep mutating but the latter stop mutating. Recall that parsing the abstract morpheme as a word marks the two phones combined closely. This paper aims to provide a synchronic analysis of Fuzhou consonant mutations, so I will leave the diachronic issue for further research.

correspondent feature to trigger phonological alternations, such as spirantization, lateralization, and palatalization.[10] Third, which phonological process is actually applied also depends on the onset$_{(\sigma 2)}$ consonant itself, as illustrated by (6) and (7), but it is unclear which features of onset$_{(\sigma 2)}$ consonants trigger the alternations. For example, [t], [s] and [ts] are alveolar consonants. However, [t] and [s] are lateralized to [l], but [ts] is spirantized, voiced, palatalized to [ʒ]. Fourth, whether two adjacent phones undergo the process of mutation may be determined by the syntax and meanings.

2.3 Previous analyses: lenition

Consonant mutations are attributed to the lenition of onset $_{(\sigma 2)}$ consonant (Chen 1990, 1998, 2010; Dai 2010, among others). Simply speaking, the constriction formed by the articulators is reduced, the features of rime$_{(\sigma 1)}$, such as [+voiced] or [nasal], can spread to the onset $_{(\sigma 2)}$ consonants (i.e., progressive manner assimilations). Hence, onset $_{(\sigma 2)}$ consonants become voiced and continuant when preceded by the rime$_{(\sigma 1)}$ V, and they become nasals if following the rime$_{(\sigma 1)}$ Vŋ.

This analysis predicts that onset $_{(\sigma 2)}$ consonants with the same place of articulation would change into the same voiced consonant. However, in the contex of the rime$_{(\sigma 1)}$ V or Vʔ, alveolar affricates [ts, ts^h] are spirantized to [ʒ] but alveolar stops [t, t^h] and fricatives [s] mutate to [l]. Besides, when the rime$_{(\sigma 1)}$ is Vŋ, alveolar stops [t, t^h] and fricatives [s] are nasalized to [n] but alveolar affricates [ts, ts^h] are still spirantized to [ʒ].

Previous researches actually notice these problems. Chen (1990, 1998) suggest that these exceptions are attributed to the difference of transcription. Alveolar affricates actually mutates to [z] when preceded by the rime$_{(\sigma 1)}$V or Vʔ, and to [nz] when following the rime$_{(\sigma 1)}$ Vŋ. However, his suggestion is not compatible to most previous studies (Liang 1983, 1986; Feng 1993; Li, Liang, Zou and Cheng 1995; Li and Feng 1998; Feng 1993; Li 2000; Dai 2010).

Other researches propose a diachronic explanation for these exceptions. For example, Chen (2010) and Dai (2010) suggest that the affricates' place of articulation before 1930s is not an alveolar as [s] and [t] but a place between alveolar and post-alveolar (Maclay & Baldwin 1870; Karlgren 1995). Besides, Norman (1977) mentions that in Ningde and Fuan dialect, both of which are Eastern Min dialects, the affricate [ts, ts^h] actually sounds like [tʃ, tʃ^h] of Guangdong dialects. In that era, the progressive assimilation is applied to the post-alveolar affricate [tʃ, tʃ^h] and other alveolar consonants [t, t^h, s], yielding the voiced post-alveolar fricative [ʒ] and alveolar lateral [l] respectively. In the latter stages, the post-alveolar affricates change into the alveolar affricates [ts], but the corresponding mutated form has not changed into the alveolar lateral [l] yet, resulting in the mutation from [ts, ts^h] to [ʒ].

Previous analyses are interesting and seem to explain the consonant mutations in Fuzhou. However, they are confronted with the following problems. First, given the universal generalization that onset is a strong position and coda is a weak position, it is not without problem to assume a progressive

[10] Vowels are voiced and continuant, but they do not have the [+continuant] or [+voiced] feature (Kenstowicz 1996).

assimilation from coda to onset.

Second, Fuzhou is a typical iambic language. This proposal can be supported by the following facts. One is the regressive tone sandhi. To speak more clearly, Fuzhou contains seven tones and it shows a regressive tone sandhi for two adjacent tones, as shown by (11-12) (Liang and Feng 1996; Li and Feng 1998).

(11) 7 tones in Fuzhou

44	ka 'home'	32	ka 'fake'	212	kuɔi 'expensive'	23	tɔʔ 'table'
53	mi 'puzzle'			242	kuɔi 'closet'	5	paʔ 'white'

(12) Tone sandhi in Fuzhou[11]

芹菜 kʰyŋ$^{53-21}$ ʒai^{212} 'celery' 皮包 pʰuoi$^{53-44}$ βau^{44} 'wallet'
馬母 ma$^{32-24}$ mo^{32} 'mare' 青菜 tsʰaŋ$^{44-53}$ ʒai^{212} 'vegetable'
出色 tsʰuʔ$^{23-5}$ saiʔ^{23} 'outstanding' 肉餅 nyʔ$^{5-32}$ piaŋ^{32} 'meat cake'

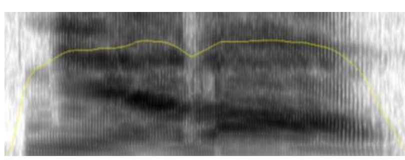
Besides, Fuzhou performs regressive rime alternations. That is, it is the rime in the first syllable that undergoes alternations instead of the rime in the second syllable. If the rime$_{(\sigma1)}$ has a 'lax' form (cf. (3)) and the tone happens to be 212, 242 or 23, the rime$_{(\sigma1)}$ changes into the 'tense' form, as illustrated in (13) (Liang and Feng 1996: 12).

(13) Rime alternations in Fuzhou

兔 tʰou^{212} 兔毛 tʰu$^{212-24}$ mo^{53} 'lapin'
筆 pεiʔ^{23} 筆盒 piʔ$^{23-21}$ aʔ^{5} 'pencil box'
事 søy^{242} 事業 sy$^{242-44}$ ŋiεʔ^{5} 'enterprise'

Moreover, compared with the first syllable, the amplitude and duration of the second syllable are not compressed at all, as shown by the spectrum below.

(14) [ŋieˀ lau] 'forehead' (mutated from [ŋieˀ tʰau])



The three pieces of evidence suggest that in Fuzhou the second syllable is prosodically stronger than the first syllable. Therefore, it is dubious to suggest that Fuzhou consonant mutations are derived from the process of lenition or assimilation on the onset of the second syllable.

[11] The tone sandhi system in Fuzhou is presented as the following table (Liang & Feng 1996).

(i) Tone sandhi in Fuzhou

σ1 \ σ2	44	53, 5	32	212, 242,23
44, 212, 242, 23	$44_{\sigma1}$ $44_{\sigma2}$	$44_{\sigma1}$ $44_{\sigma2}$	$53_{\sigma1}$ $44_{\sigma2}$	$53_{\sigma1}$ $44_{\sigma2}$
53, 5	$44_{\sigma1}$ $44_{\sigma2}$	$32_{\sigma1}$ $44_{\sigma2}$	$32_{\sigma1}$ $44_{\sigma2}$	$21_{\sigma1}$ $44_{\sigma2}$
32, 23	$21_{\sigma1}$ $44_{\sigma2}$	$21_{\sigma1}$ $44_{\sigma2}$	$24_{\sigma1}$ $44_{\sigma2}$	$44_{\sigma1}$ $44_{\sigma2}$

Third, it is well-known that lenition includes the following phonological processes (Kirchner 2004): degemination (e.g. tː → t), flapping (e.g. t → ɾ), spirantization (e.g. t → {θ, θ̞}), reduction of other consonants to approximants (e.g. r → ɹ, s → s̞), debuccalization (t → ʔ, s → h), elision (e.g. t → ϕ) and voicing (e.g. t → d). Although consonant mutations of Fuzhou triggered by the rime$_{(\sigma1)}$ V or Vʔ (cf. (6)) follow from the lenition analysis, nasalization triggered by the rime$_{(\sigma1)}$ Vŋ is not included in the process of lenition. Therefore, it may be problematic to explain all consonant mutations by the lenition approach.

Fourth, it is unclear which phonological process is chosen the various phonological alternations of lenition. For example, the onset$_{(\sigma2)}$ [p] is spirantized to [β], [t] is lateralized to [l], but [k] is deleted. Why should it be the case? It seems that this inconsistence may be accounted by diachronic derivation. Voiceless stops are spirantized (e.g. [p] → [β]) in the first stage, and then become laterals (e.g. [t] → [l]) or are totally deleted (k → ϕ) in the latter stages. In order to undergo the diachronic derivation, Fuzhou consonant mutations should exist for a long time. However, Chen (2010) argues that this phenomenon occurred around the 19th century, based on the description in Maclay & Baldwin (1987). Maclay and Baldwin explicated the rules of tone sandhi in detail at the beginning of their book, but they only briefly mentioned Fuzhou consonant mutations at the end of their book. As we know, consonant mutation is also a significant phonological phenomenon in Fuzhou, so it is impossible that Maclay and Baldwin did not explain the rules clearly if it is a well-established principle at that time. Therefore, it is plausible to suggest that consonant mutations are just developing around the 19th century.

The discussion above suggests that Fuzhou consonant mutations may not be resulted from assimilation or lenition because onset is the strong position and Fuzhou is an iambic language. Besides, this phenomenon started just from the 19th century, so diachronic analysis may not be plausible.

In the followings, this paper will provide a synchronic analysis of Fuzhou consonant mutations. The basic idea is that consonant mutations are resulted from docking floating features on consonants, along the line of Autosegmental Theory (Wolf 2007). The floating features are the phonological realization of an abstract morpheme expressing the meaning that the two adjacent morphemes have a close morphological relation. This paper proposes that the inconsistency of phonological alternations is accounted for by the Dispersion Theory (Flemming 2004), which emphasizes the importance of minimizing perceptual confusion.

3. An autosegemental analysis of consonant mutations in Fuzhou

In this section, I will briefly introduce the autosegmental theory of mutation proposed by Wolf (2007), and apply this theory to the consonant mutations in Fuzhou. Then, I will point out some exceptions.

3.1 The Autosegemental Theory of mutations (Wolf 2007)

Autosegmental theory treats mutations as a requirement of docking all floating features onto segments (Wolf 2007). Wolf formalizes this idea by a faithfulness constraint MAXFLT, which is a special case of MAX (Feature), and a markedness constraint *FLOAT. Please consider (15).

(15) a. MAXFLT: All autosegments that are floating in the input have output correspondents.
b. *FLOAT: No floating autosegments in the output.

Deleting floating features violates MAXFLT; preserving floating features but leaving them floating violates *FLOAT. For example, Aka, a Bantu language, marks the singular of noun class 5 by voicing root-initial consonants. Wolf suggests that this morpheme is realized as a floating feature in the input, which must dock on the root-initial consonant to satisfy the undominated constraints: MAXFLT and *FLOAT.

Besides, Wolf proposes an additional constrain NOVACDOC to extend his theory to phenomena triggered by the exchange rule, which convert +F segments to –F and –F segments to +F in the same environment. He suggests that this process originates from the selection of allomorphs (i.e., sets of floating features) listed in the inventory. Crucially, this selection should satisfy NOVACDOC, as shown by (16). For example, in DhoLuo, a Nilotic language, the Plural morphemes reverse the voicing value of the last consonant in the stem, as shown by (17) (Wolf 2007: (27)).

(16) NOVACDOC: Floating features cannot dock onto segments that already bore the same feature value in the input.

(17) Feature polarity in DhoLuo

Nom.Sg.	bat	kidi
Nom.Pl.	bede	kite
	'arm'	*'stone'*

The Plural morpheme have two listed allomorphs: {[+voi]E, [-voi]E}. In order to satisfy NOVACDOC, nominative plural forms of *bat* and *kidi* pick the allomorph [+voi]E and [-voi]E respectively. Otherwise, docking [-voi] to [t] in 'bat' with the feature [-voi] violates NOVACDOC.

In addition, Wolf (2007: 40) notes that "an arbitrary preference between these allomorphs will be required. Following McCarthy & Prince (1993: ch. 7) and McCarthy & Wolf (2005: §6.1), … the allomorphs do not compete in a single tableau but that instead the higher-priority allomorph is 'tried first', and lower-priority allomorphs tried as inputs only if the input with the higher priority allomorph maps to the null output". This principle is motivated by the vowel alternation in Sibe. There are five suffixes whose initial consonant is uvular if the base contains a [+low] vowel, but which is velar otherwise, as shown by (18) (Wolf 2007:59).

(18) utu-<u>xu</u> 'dress.SELF-PERCEIVED IMMEDIATE PAST'
lavdu-<u>χu</u> 'become more.SELF-PERCEIVED IMMEDIATE PAST'

The morpheme contains two allomorphs: {[+low] χV, xV}. The former fails to surface if the root contains no low vowels. That is, the uvular allomorph always appears unless penalized by violation of the undominated constraints IDENT(low) or DEP. Therefore, [+low] χV is the higher priority allomorph and xV is the lower one.

This paper will use these three constraints, MAXFLT, *FLOAT and NOVACDOC and the concept of arbitrary preference of allomorphs to explain consonant mutations in Fuzhou dialect.

3.2 Consonant mutations in Fuzhou

In the line of Autosegmental Theory, I suggest that Fuzhou consonant mutations are resulted from docking floating features on onset$_{(\sigma2)}$ consonants. The floating features are the phonological realization of an abstract morpheme denoting that the two adjacent phones have a close relationship. Morphologically, if the abstract morpheme is parsed on two adjacent phones, they are structured as a word instead of a phrase, as illustrated by the contrast within the table (9). Semantically, parsing this abstract morpheme into two phones in sequence specifies that the word has an extended meaning. On the other hand, if the abstract morpheme is not parsed into a word, the word has the original meaning, as shown by the contrast in (10).

Given the morphological and semantic differences, it is plausible to suggest that there is an abstract morpheme within a word whose realization is floating features. I suggest that the abstract morpheme has three listed allomorphs: {[+continuant, +voiced], [+sonorant], ϕ} (henceforth {[+cont, +voi], [+son], ϕ}), in which the allomorph ϕ means that it does not have any phonetic form. Among the allomorphs, [+cont, +voi] is the first priority allomorph, [+son] is the second one and ϕ is the last one. Different allomorph is chosen according to the type of rime$_{(\sigma1)}$ and onset$_{(\sigma2)}$ in a word.

3.2.1 The rime(σ1): V

When the rime$_{(\sigma1)}$ is V, several phonological processes are applied to onset$_{(\sigma2)}$ consonants, as shown by (19).

(19) Consonant mutations (rime $_{(\sigma1)}$: Vʔ)

Rime$_{(\sigma1)}$	Onset $_{(\sigma2)}$	Alternations	Onset $_{(\sigma2)}$	Alternations
Vʔ	p, p^h → [β]	spirantization, voicing	ts, ts^h → [ʒ]	spirantization voicing, palatalization
	t, t^h, s → [l]	lateralization, voicing		
	k, k^h, h → ϕ	deletion	m, n, ŋ, l → --	no change

Bilabial stops [p, p^h] are voiced and spirantized to a voiced bilabial fricative [β]. Alveolar stops [t, t^h], and alveolar fricatives [s] are voiced and lateralized into [l]. Alveolar affricates [ts, ts^h] are voiced, spirantized and palatalized to a voiced post-alveolar fricative [ʒ]. Velar stops [k, k^h] and glottal fricatives [h] are deleted. Laterals [l] and nasals [m, n, ŋ] do not undergo any change.

As for the mutation from [p] to [β], GEN first takes the allomorph$_1$ [+cont,

+voi] as the input. These floating features must dock on the consonant, or the form will be penalized by MAXFLT and *FLOAT, as in (15) (repeated as (20)).

(20) a. MAXFLT: All autosegments that are floating in the input have output correspondents.
b. *FLOAT: No floating autosegments in the output.

Satisfying these two constraints will violate the faithfulness constraints: IDENT (voi) and IDENT (cont), as listed by (21). Thus, these two faithfulness constraints are dominated by MAXFLT and *FLOAT; otherwise, no alternation would happen, as shown by (22), where [p] mutates to [β].

(21) a. IDENT (voi): Correspondent segments are identical in [voice].
b. IDENT (cont): Correspondent segments are identical in [continuant].

(22) 'earpick' with allomorph$_1$ [+cont, +voi]

Input: /ŋi [+cont, +voi] +pa/	MAXFLT	*FLOAT	IDENT (voi)	IDENT (cont)
a. ŋi ~~[+cont]~~ ~~[+voi]~~ pa	[+cont]! [+voi]			
b. ŋi ~~[+voi]~~ ɸa [+cont]	[+voi]!		*	
c. ŋi ~~[+cont]~~ ba [+voi]	[+cont]!			*
d. ŋi [+cont] [+voi] pa		[+cont]! [+voi]		
e. ŋi [+voi] ɸa [+cont]		[+voi]!	*	
f. ŋi [+cont] ba [+voi]		[+cont]!		*
g. ☞ ŋi βa [+cont] [+voi]			*	*

Candidates (a-c) are penalized because the floating features are deleted. For candidates (d-f), the floating features are floating in the output, which violates *FLOAT, so these candidates are ruled out. The optimal candidate (g) docks both floating features to onset$_{(\sigma2)}$ consonants, satisfying the undominated constraints.

As for the onset$_{(\sigma2)}$ [s], choosing the allomorph$_1$ [+cont, +voi] cannot generate an optimal output because docking the floating feature [+cont] to [s], which already has the feature [+cont], will violate NOVACDOC, as stated by (16) (repeated as (23)).

(23) NOVACDOC: Floating features cannot dock onto segments that already bore the same feature value in the input.

In order to satisfy NOVACDOC, MAXFLT and *FLOAT, allomorph$_1$ is not parsed. This phonological treatment violates the constraint MPARSE is, which requires that all morphemes should be parsed by words. Since [s] does not mutate to [z], MPARSE is dominated by NOVACDOC, MAXFLT and *FLOAT, as shown by (24). In order to simplify the discussion, I assume that no feature can be preserved but floating in the output. Therefore, candidates with floating features and the constraint *FLOAT will not be included in the following discussion.

(24) 'flint' with allomorph$_1$ [+cont, +voi] (Take1)

Input: /huoi [+cont]$_1$, [+voi]$_2$ +suoʔ/ [-voi]$_3$[+cont]$_4$	MAXFLT	NOVACDOC	MPARSE	IDENT (voi)	IDENT (cont)
a. huoi ~~[+cont]$_1$~~, ~~[+voi]$_2$~~ suoʔ	[+cont]$_1$! [+voi]$_2$				
b. huoi ~~[+cont]$_1$~~ zuoʔ [+voi]$_2$ [+cont]$_4$	[+cont]$_1$!			*	
c. huoi ~~[+voi]$_2$~~ suoʔ [-voi]$_3$ [+cont]$_{1,4}$	[+voi]$_2$!	[+cont]$_1$!			
d. huoi zuoʔ [+voi]$_2$ [+cont]$_{1,4}$		[+cont]$_1$!		*	
e. ☞ Null Parse			*		

Candidates (a-c) and (d) are ruled out by MAXFLT and NOVACDOC, respectively, the candidate e of null output wins.

Since the first priority allomorph [+cont, +voi] fails to surface, GEN takes the second priority allomorph [+son] as the input. Docking the floating feature to [s], which is not sonorant, will not violate NOVACDOC, so it is possible to produce an attested surface form, as shown by the following tableau.

(25) 'flint' with allomorph$_2$ [+son] (Take2)

Input: /huoi [+son]+suoʔ/	MAXFLT	NOVACDOC	IDENT (voi)	IDENT (cont)	IDENT (son)
a. huoi ~~[+son]~~ suoʔ	[+son]!				
b. huoi nuoʔ [+son] [nas]			*	*!	*
c. ☞ huoi luoʔ [+son] [lat]			*		*

Deleting the floating feature [+son] violates MAXFLT, so candidate (a) is ruled out. Notice that docking [+son] to an obstruent may change it into a nasal or a lateral. Lateralization, which results in a continuant consonant, is better than nasalization, which produces a noncontinuant consonant, because the former still satisfies the faithfulness constraint IDENT (cont) but the later violates it. Thus, candidate (c) is the optimal candidate.

If the onset$_{(\sigma2)}$ consonant is a lateral or a nasal, it will not undergo change.

(26) ‘hen’ with allomorph$_1$ [+cont, +voi] (take 1)

Input: /kie + [+cont]$_1$, [+voi]$_2$ + mo / [+voi]$_3$ [-cont]$_4$	MAXFLT	NOVA CDOC	MPA RSE
a. kie ~~[+cont]$_1$~~, ~~[+voi]$_2$~~ mo	[+cont]$_1$! [+voi]$_2$		
b. kie ~~[+voi]$_2$~~ βo [+voi]$_3$ [+cont]$_1$	[+voi]$_2$!		
c. kie βo [+voi]$_{2,3}$ [+cont]$_1$		[+voi]$_2$!	
d. ☞ Null Parse			*

(27) ‘hen’ with allomorph$_2$ [+son] (take 2)

Input: /kie + [+son]$_1$ + mo / [+son]$_2$	MAXFLT	NOVACDOC	MPARSE
a. kie ~~[+son]$_1$~~ mo [+son]$_2$	[+son]$_1$!		
b. kie mo [+son]$_{1, 2}$		[+son]$_2$!	
c. ☞ Null Parse			*

(28) ‘deal with’ with allomorph$_1$ [+cont, +voi] (take 1)

Input: /ts^{h}y + [+cont]$_1$,[+voi]$_2$ +li / [+voi]$_3$ [+cont]$_4$	MAXFLT	NOVAC DOC	MPA RSE
a. ts^{h}y ~~[+cont]$_1$~~, ~~[+voi]$_2$~~ li	[+cont]$_1$! [+voi]$_2$		
b. ts^{h}y ~~[+cont]$_1$~~ di [+voi]$_{2,3}$ [+cont]$_4$	[+cont]$_1$!	[+voi]$_2$!	
c. ts^{h}y ~~[+voi]$_2$~~ li [+voi]$_3$ [+cont]$_{1,4}$	[+voi]$_2$!	[+cont]$_1$!	
d. ts^{h}y li [+voi]$_{2,3}$ [+cont]$_{1,4}$		[+cont]$_1$! [+voi]$_2$	
e. ☞ Null Parse			*

(29) ‘deal with’ allomorph$_2$ [+son] (take 2)

Input: / ts^{h}y + [+son]$_1$ + li / [+son]$_2$	MAXFLT	NOVACDOC	MPARSE
a. ts^{h}y ~~[+son]$_1$~~ li [+son]$_2$	[+son]$_1$!		
b. ts^{h}y li [+son]$_{1, 2}$		[+son]$_2$!	
c. ☞ Null Parse			*

Both allomorphs fail to surface because docking on them the [+voi] feature of the allomorph$_1$ or the [+son] feature of the allomorph$_2$ violates NOVACDOC. Besides, deleting the floating features violates MAXFLT. Therefore, GEN takes allomorph$_3$ ϕ as the input, and hence [l] and nasals do not undergo any change. Please see tableaux (25-29).

As for the onset$_{(\sigma 2)}$ consonant [k], the mutation process is more complicated. The grammar predicts that [k] will mutate to [ɣ], as shown by (30).

(30) 'boar' with allomorph$_1$ [+cont, +voi]

Input: /ty [+cont], [+voi] + kɔyʔ/	MAXFLT	NOVA CDOC	MPA RSE	IDENT (cont)	IDENT (voi)
a. ty ~~[+cont]~~ ~~[+voi]~~ kɔyʔ	[+cont]! [+voi]				
b. ty ~~[+cont]~~ gɔyʔ [+voi]	[+cont]!				
c. ty ~~[+voi]~~ xɔyʔ [+cont]	[+voi]!				
d. 💣 ty ɣɔyʔ [+cont] [+voi]				*	*
e. Null Parse			*!		

Candidate (d) should be the optimal output because it satisfies all the higher ranked constraints (i.e., MAXFLT, NOVACDOC) and only violates the dominated ones (i.e., IDENT (cont), IDENT (voi)). Other candidates either violate MAXFLT, NOVACDOC or MPARSE, so they are ruled out. However, this predication is contradictory to the real output. [k] is deleted in this environment instead of changed into [ɣ]. An apparent possible explain is that [ɣ] is not a phoneme in Fuzhou. However, [β] and [ʒ] are not phoneme in Fuzhou, but [p] still mutates to [β] and [ts] mutates to [ʒ]. Therefore, attributing the mutation of onset [k] to the consonant inventory is not convincing.

This paper suggests that the deletion of [ɣ] is resulted from the confusion of [ɣ] and vowels. Crucially, the articulators pronouncing allophonic fricatives are not as close as the ones of pronouncing phonemic fricatives (Chen, 1990), so it is possible that the articulation only involves a degree of aperture quite close to vocalization, just as [β̞, ð̞, ɣ̞] in Spanish (Piñeros 2002). Compared to bilabial and palatal approximants [β̞] and [ʒ̞], the velar approximant [ɣ̞] has fewer strictures to distinguish it from vowels. Therefore, it is difficult to distinguish [ɣ̞] and vowels, yielding the deletion of [ɣ̞] in the onset.

This suggestion can be supported by the following phenomenon. [ŋ] cannot occur in the syllable onset positions in Tagalog. Zuraw (2010) argues that the restriction is motivated by the confusion of the onset [ŋ] with vowels. Since the oral cavity is blocked off by the uvular closure, the resonating cavity during producing the backest nasal uvular [ɴ] is approximately a single tube from the glottis through the pharynx and nasal cavity to the nostrils. This resonating cavity results in a vowel-like formant structure. Compared with [m], [ŋ] only has a very short oral side tube, so [ŋ] is easily to be confused with vowels. The prohibition of [ŋ] from the onset position suggests that if it is difficult to distinguish two phones in certain position, one of the phones will not occur in that place.

So far, the autosegmental theory seems to successfully explain the consonant mutations in Fuzhou. However, the mutations of alveolar stops [t, t^h], and alveolar affricates [ts, ts^h] pose problems. The grammar predicts that these four phones would mutate to [z], as shown by the tableaux below.

(31) 'girl' with allomorph$_1$ [+cont, +voi]

Input: /a [+cont, +voi] + t^hau /	MAXFLT	NOVA CDOC	MPA RSE	IDENT (cont)	IDEN T(voi)
a. a ~~[+cont]~~ ~~[+voi]~~ t^hau	[+cont]! [+voi]				
b. a ~~[+voi]~~ sau [+cont]	[+voi]!			*	
c. a ~~[+cont]~~ dau [+voi]	[+cont]!				*
d. 💣 a zau [+cont] [+voi]				*	*
e. Null Parse			*!		

(32) 'mouse' with allomorph$_1$ [+cont, +voi]

Input: /lo [+cont]$_1$[+voi]$_2$+ ts^hy/ [-cont]$_3$ [+cont]$_4$	MAXFL T	NOVAC DOC	MP AR SE	IDE NT(c ont)	IDE NT (voi)
a. lo ~~[+cont]$_1$~~ ~~[+voi]$_2$~~ ts^hy [-cont]$_3$ [+cont]$_4$	[+cont]$_1$![+voi]$_2$				
b. lo ~~[+voi]$_2$~~ ts^hy [-cont]$_3$ [+cont]$_{1,4}$	[+voi]$_2$!	[+cont]$_1$!			
c. lo ~~+cont]$_1$~~ dz^hy [-cont]$_3$ [+cont]$_4$ [+voi]$_2$	[+cont]$_1$!				*
d. 💣 lo zy [+cont]$_1$ [+cont]$_4$ [+voi]$_2$				*	*
e. Null Parse			*!		

The allomorph$_1$ [+cont, +voi] is parsed in both (31) and (32). Any candidate deleting the floating features is penalized because of violating MAXFLT (cf. (31a-c), (32a-c)). The null output (cf. (31e) and (32e)) are ruled out by violating MPARSE. Therefore, candidate (d) is the optimal output for the inputs of (31) and (32) because they satisfy the higher ranked constraints: MAXFLT, NOVACDOC and MPARSE. Some attentive readers may wonder whether docking [+cont] to affricates [ts, ts^h] violates NOVACDOC or not. The answer is not. Affricates have a sequence of [-continuant] and [+continuant] features (Kenstowicz 1996; Sagey 1986), so the floating feature [+cont]$_1$ actually replaces the [-cont]$_3$ intrinsically possessed by [ts], as shown by

(32d).Unfortunately, this prediction is not the real output of consonant mutations of alveolar stops and alveolar affricates. Instead, the former mutates to [l], and the latter mutates to [ʒ] (cf. (6)).

The autosegmental theory can explain most cases of Fuzhou consonant mutations. However, it is still unclear why alveolar stops mutate to [l], and alveolar fricatives mutate to [ʒ]. In section 4, I will provide an analysis combining the autosegmental theory and the dispersion theory to solve this problem.

3.2.2 The rime(σ1): Vŋ

When the rime $_{(\sigma1)}$ is Vŋ, onset$_{(\sigma2)}$ consonants are nasalized except for alveolar affricates [ts] and [ts^h], as shown by (7) (summarized as (33) below).

(33) Consonant mutations (rime $_{(\sigma1)}$: Vŋ)

Rime $_{(\sigma1)}$	Onset $_{(\sigma2)}$	Alternations	Onset $_{(\sigma2)}$	Alternations
Vŋ	p, p^h → [m]	nasalization	ts, ts^h → [ʒ]	voicing spirantization palatalization
	t, t^h, s, l → [n]	nasalization		
	k, k^h, h → [ŋ]	nasalization		
	m, n, ŋ → --	no change		

Along the line of the autosegemental theory, onset$_{(\sigma2)}$ consonants should have the same mutated pattern regardless of the type if the rime $_{(\sigma1)}$.

(34) 'father' with allomorph$_1$ [+cont, +voi]

Input: /louŋ [+cont]$_1$, [+voi]$_2$ +pa/ [-voi]$_3$[-cont]$_4$	MAXFLT	NOVACDOC	MPARSE	IDENT(voi)	IDENT(cont)
a. louŋ ~~[+cont]$_1$~~, ~~[+voi]$_2$~~ pa	[+cont]$_1$! [+voi]$_2$				
b. louŋ ~~[+cont]$_1$~~ ba [+voi]$_2$ [-cont]$_4$	[+cont]$_1$!			*	
c. louŋ ~~[+voi]$_2$~~ ɸuoʔ [-voi]$_3$ [+cont]$_1$	[+voi]$_2$!				*
d. 💣 louŋ βuoʔ [+voi]$_2$ [+cont]$_1$				*	*
e. Null Parse			*!		

For example, bilabial stops [p] [p^h] should mutate to [β] by docking the floating features [+cont, +voi], as shown by (34). Candidate (d) should be the optimal output because all floating features dock on the onset. However, the prediction is not born out (cf. (33)). Therefore, there must be some constraint penalizing the sequence of [ŋ] and the following mutated onset.

Crosslinguistically, the sequence of nasals and continuant consonant, such as fricatives, laterals, liquids, is disfavored (Passy 1890, Ohala 1997). For example, a stop may be inserted or emerges between a nasal and a fricative in English, such as *warmth* [wɔrmp̲θ]. Moreover, the sequence nasal and lateral [l] also triggers the emergent stop in Latin, such as *temp̲lum* 'a section'. Besides, French shows the emergence stop between nasals and retroflex [r], such as *chamb̲re* 'room'. Articulatorically, it is difficult to pronounce the nasals fricatives sequence. The articulations of nasals involve a lowered velum and a total block in the oral cavity, but continuant consonants are opposite, involving a raised velum and a release of the block in the oral cavity.[12] It is not easy to produce nasal fricatives or nasal laterals. Therefore, sequences of nasals and continuant consonants are avoided in languages.

Based on the typological and aerodynamic evidences, the sequence of nasals and fricatives is marked. This paper formalize this restriction by the markedness constraint *NC$_{[+cont]}$, as listed in (35). *NC$_{[+cont]}$ is an undominated constraint because no sequence of nasals and fricatives can surface. Please the tableau (36).

(35) *NC$_{[+cont]}$: No nasal- continuant consonant sequence.

(36) 'father' with allomorph$_1$ [+cont, +voi] (take 1)

Input: /louŋ [+cont]$_1$, [+voi]$_2$+pa/ [-voi]$_3$[-cont]$_4$	*NC$_{[+cont]}$	MAXFLT	NOVACDOC	MPARSE	IDENT (voi)	IDENT (cont)
a. louŋ ~~[+cont]$_1$~~, ~~[+voi]$_2$~~ pa		[+cont]$_1$! [+voi]$_2$				
b. louŋ ~~[+cont]$_1$~~ ba [+voi]$_2$ [-cont]$_4$		[+cont]$_1$!			*	
c. louŋ ~~[+voi]$_2$~~ ɸuoʔ [-voi]$_3$ [+cont]$_1$		[+voi]$_2$!				*
d. louŋ βuoʔ [+voi]$_2$ [+cont]$_1$	*!				*	*
e. ☞ Null Parse				*		

Candidates (a-c) are penalized due to violations of MAXFLT. Although candidate (d) satisfies MAXFLT, it is ruled out by * NC$_{[+cont]}$. Since the four candidates all violate higher ranked constraints, candidate (e) is the optimal output in which the allomorph is not parsed by words.

Then, GEN takes the lower priority candidate [+son] as the input. Please see the tableau below.

---

[12] The emergent stop observed in English, Latin and French above is an immediate state emerging between the initial state in which a nasal is pronounced and the final state in which a fricative is pronounced (Ohala 1997). In the initial state, the velum is lowered and there is a total block in the oral cavity. In the final state, the velum is raised and the block in the oral cavity is released. Therefore, the immediate state is formed naturally in which the velum is raised and the closure in the oral cavity maintains, yielding the phone of a stop.

(37) ‘father’ with allomorph$_2$ [+son] (take 2)

Input: /louŋ [+son]+pa/	*NC$_{[+cont]}$	MAXFLT	NOVACDOC	MPARSE	IDENT (son)
a. louŋ ~~[+son]~~ pa		[+son] !			
b. ☞ louŋ ma [+son]					*
c. Null Parse				*!	

In order to docking [+son] on the onset, [p] should mutate to [m]. Notice that [m] is the only sonorant consonant with the bilabial place of articulation. Besides, the sequence of the coda$_{(\sigma1)}$ [ŋ] and the mutated onset$_{(\sigma2)}$ [m] satisfies * NC$_{[+cont]}$. Thus candidate (b) wins out.

The mutation of the onset$_{(\sigma2)}$velar stops to [ŋ] can be explained by the same analysis. Docking the higher priority allomorph [+cont, +voi] on the onset may generate the illicit output which contains a sequence of nasals and fricatives. Therefore, the null output is the optimal candidate, as shown by (38).

(38) ‘steam’ with allomorph$_1$ [+cont, +voi] (take 1)

Input: / tsiŋ [+cont], [+voi] + kʰεi/	*NC$_{[+cont]}$	MAXFLT	NOVACDOC	MPARSE	IDENT (cont)	IDENT (voi)
a. tsiŋ ~~[+cont]~~ ~~[+voi]~~ kʰεi		[+cont]! [+voi]				
b. tsiŋ ~~[+cont]~~ gεi [+voi]		[+cont]!				*
c. tsiŋ ~~[+voi]~~ xεi [+cont]	*!	[+voi]			*	
d. tsiŋ ɣεi [+cont] [+voi]	*!				*	*
e. ☞ Null Parse				*		

In turns to lower priority allomorph [+son], docking [+son] to velar stops changes the consonant into [ŋ], as shown by (39), where candidate (b) is the optimal candidate.

(39) ‘steam’ with allomorph$_2$ [+son] (take 2)

Input: / tsiŋ [+son] + kʰεi /	*NC$_{[+cont]}$	MAXFLT	NOVACDOC	MPARSE	IDENT (son)
a. tsiŋ ~~[+son]~~ kʰεi		[+son] !			
b. ☞ tsiŋ ŋεi [+son]					*
c. Null Parse				*!	

Alone this line, the higher priority allomorph [+cont, +voi] cannot dock on [t] because the output will violate * NC$_{[+cont]}$. Thus, the candidate of null parse wins out, as illustrated by (40).

(40) ‘New Year’s Day’ with allomorph$_1$ [+cont, +voi] (take 1)

Input: /ŋuoŋ [+cont], [+voi]+taŋ /	*NC$_{[+cont]}$	MAXFLT	NOVACDOC	MPARSE	IDENT (cont)	IDENT(voi)
a. ŋuoŋ ~~[+cont]~~ ~~[+voi]~~ taŋ		[+cont]! [+voi]				
b. ŋuoŋ ~~[+cont]~~ daŋ [+voi]		[+cont]!			*	
c. ŋuoŋ ~~[+voi]~~ saŋ [+cont]	*!	[+voi]			*	
d. ŋuoŋ zaŋ [+cont] [+voi]	*!				*	*
e. ☞ Null Parse				*		

Then, the lower priority allomorph [+son] is fed to GEN as an input. There are three alveolar sonorant consonants: [n], and [l]. [n] is noncontinuant, while [l] is continuant. Therefore, [t] can only mutate to [n] in order to satisfy *NC$_{[+cont]}$. Please consider the tableau below.

(41) ‘New Year’s Day’ with allomorph$_2$ [+son] (take 2)

Input: / ŋuoŋ [+son] + taŋ /	*NC$_{[+cont]}$	MAXFLT	NOVACDOC	MPARSE	IDENT (son)
a. ŋuoŋ ~~[+son]~~ taŋ		[+son]!			
b. ŋuoŋ laŋ [+son]	*!				*
c. ☞ ŋuoŋ naŋ [+son]					*
d. Null Parse				*!	

Similarly, the onset$_{(\sigma 2)}$ [s] mutates to [n] instead of [l] in order to satisfy *NC$_{[+cont]}$, as presented by (42). Note that the lower priority allomorph [+son] is chosen rather than the higher one [+cont, +voi] for the satisfaction of MAXFLT and NOVACDOC.

(42) ‘ginseng’ with allomorph$_2$ [+son] (take 2)

Input: / yoŋ [+son] + sɛi /	*NC$_{[+cont]}$	MAXFLT	NOVACDOC	MPARSE	IDENT (son)
a. yoŋ ~~[+son]~~ sɛi		[+son]!			
b. yoŋ lɛi [+son]	*!				*
c. ☞ yoŋ nɛi [+son]					*
d. Null Parse				*!	

In terms of the onset$_{(\sigma2)}$ nasals, they are immune to mutation because docking allomorph$_1$ [+cont, +voi] or allomorph$_2$ [+son] violates MAXFLT or NOVACDOC. Therefore, GEN takes allomorph$_3$ ϕ as the input.

Although [l] as onset$_{(\sigma2)}$ is docked allomorph$_3$ ϕ and remains the original forms, the sequence [ŋ$_{(\sigma1)}$.l$_{(\sigma2)}$] still violates the undominated constraint *NC$_{[+cont]}$. In order to satisfy *NC$_{[+cont]}$, [l] mutates to [n]. Please consider (43).

(43) ‘gold necklace’

Input: / kiŋ liɛŋ/	*NC$_{[+cont]}$	IDENT (nas)	IDENT (lat)
a. kiŋ liɛŋ	*!		
b. kiŋ niɛŋ		*	*

Indeed, there are other repairing strategies, such as inserting a vowel, or deleting [l] or [ŋ]. However, only changing the manner of articulation of the input is the most faithful option and hence is the most economical than other strategies. Thus, this repairing strategy is chosen instead of the others.

The constraint ranking establish above may predict that the alveolar affricate [ts] and [ts^h] should also mutate to [n], just as alveolar stops [t] and [t^h]. Docking allomorph$_1$ on [ts] or [ts^h] will produce illicit sequence [ŋ.z] (cf. (40)), which violates *NC$_{[+cont]}$, so the null output wins out. Then, allomorph$_2$ [+son] is sent to GEN, producing a licit output [ŋ.n], as shown by (44). However, the prediction is not born out (cf. [ʒ] in (33)).

(44) ‘sign’ with allomorph$_2$ [+son] (take 2)

Input: /ts^{h}ieŋ [+son] + tsɛi /	*NC$_{[+cont]}$	MAXFLT	NOVACDOC	MPARSE	IDENT (son)
a. ts^{h}ieŋ ~~[+son]~~ tsɛi		[+son]!			
b. ts^{h}ieŋ lɛi | [+son]	*!				*
c. 💣 ts^{h}ieŋ nɛi | [+son]					*
d. Null Parse				*!	

This is another case that the autosegmental theory cannot explain. I will discuss it in section 4.

3.2.3 The rime(σ1): Vk

The onset$_{(\sigma2)}$ does not undergo any alternation if the rime $_{(\sigma1)}$ is Vk, as shown by (8). Given that the morpheme must dock on the onset$_{(\sigma2)}$ consonant, the onset$_{(\sigma2)}$ consonants with the rime $_{(\sigma1)}$ Vk should have the mutated pattern as the onset$_{(\sigma2)}$ with the rime $_{(\sigma1)}$ V (cf. (6)). However, this prediction is not born out. Thus, there must be some constraints penalizing the sequence of [k] and the mutated onset$_{(\sigma2)}$ consonant.

Allomorph$_1$ and allomorph$_2$ cannot surface may be resulted from the requirement that two adjacent consonants should agree in voicing (cf. Lombardi 1999 for German, Polish, Swedish examples, Katz 1987 for Yiddish examples), as indicated by the constraint AGR-CC (voi).

(45) AGR-CC (voi): Consonant clusters should agree in voicing.

Docking allomorph$_1$ [+cont, +voi] on the onset$_{(\sigma 2)}$ yields a cluster of a voiceless consonant and a voiced consonant, so the sequence fatally violates the undominated constraint AGR-CC(voi). Therefore, candidate (b) and (d) in tableau are ruled out. Besides, deleting the floating feature will violate the high ranked constraint MAXFLT, so candidate (46a) and (46c) cannot be the optimal candidate. Hence, the null output (46e) wins out. Please see the tableau in (46), which presents the mutation of [p] with the rime $_{(\sigma 1)}$ Vk.

(46) 'pedal' with allomorph$_1$ [+cont, +voi]

Input: / tak [+cont], [+voi]+pɛiŋ /	AGR-C C (voi)	MAXF LT	NOVA CDOC	MPA RSE	IDENT (cont)	IDEN T(voi)
a. tak ~~[+cont]~~ ~~[+voi]~~ pɛiŋ		[+cont] ! [+voi]				
b. tak ~~[+cont]~~ bɛiŋ [+voi]	*!	[+cont]				*
c. tak ~~[+voi]~~ ɸɛiŋ [+cont]		[+voi]!			*	
d. tak βɛiŋ [+cont] [+voi]	*!				*	*
e. ☞ Null Parse				*		

Since allomorph$_1$ fails to be parsed by words, the lower priority allomorph$_2$ [+sor] is fed into GEN. However, sonorant consonants must be voiced, so docking the floating feature [+sor] on the onset$_{(\sigma 2)}$ also violates AGR-CC (voi), as shown by (47).

(47) 'pedal' with allomorph$_2$ [+son] (take 2)

Input: /tak [+son] + pɛiŋ/	AGR-CC (voi)	MAXF LT	NOVAC DOC	MPAR SE	IDENT (son)
a. tak ~~[+son]~~ pɛiŋ		[+son]!			
b. tak mɛiŋ [+son]	*!				*
c. ☞ Null Parse				*	

Candidate (a) and (b) fatally violates the high-ranked constraint AGR-CC (voi) and MAXFLT, respectively. Therefore, the candidate (c) wins out. As a result, when the preceding rime$_{(\sigma 1)}$ is Vk, the onset$_{(\sigma 2)}$ [p] does not undergo any mutation. This analysis can extend to the words containing nonsonorant consonants as it onset$_{(\sigma 2)}$. No matter whether they are docked by allomorph$_1$ [+cont, +voi] or allomorph$_2$ [+sor], the candidates will be ruled out by either AGR-CC (voi) or MAXFLT, except for the candidate null parse. Therefore, allomorph$_3$ ϕ is fed to GEN, so docking ϕ on the onsets$_{(\sigma 2)}$ does not cause any phonological change.

As for sonorant onset$_{(\sigma2)}$, neither allomorph$_1$ nor allomorph$_2$ can be parsed by words due to the violation of NOVACDOC (cf. (26)-(29)), so they are docked by allomorph$_3$ ϕ and do not exhibit alternations. However, the sequence of k$_{(\sigma1)}$ and sonorant onset$_{(\sigma2)}$ should still be penalized by AGR-CC (voi), but the prediction is not born out. Here is the generalization: k$_{(\sigma1)}$ and the mutation onset$_{(\sigma2)}$ should agree in voicing, but k$_{(\sigma1)}$ and the original onset$_{(\sigma2)}$ do not have the restriction. The original onset$_{(\sigma2)}$ is protected by IDENT(son) but the mutated form is not. In order to explain this effect, I suggest that AGR-CC(voi) is outranked by a conjoined constraint AGR-CC(voi) & IDENT(son). Therefore, the sequence of k$_{(\sigma1)}$ and originally sonorant onset$_{(\sigma2)}$ is protected by the undominated constraint, as shown by the tableau in (48).

(48) ts^{h}ouk miaŋ 'famous'

Input: /ts^{h}ouk miaŋ/	AGR-CC(voi) & IDENT(son)	AGR-CC(voi)	IDENT(son)
a. ts^{h}ouk piaŋ	*!		*
b. ☞ ts^{h}ouk miaŋ		*	

In order to satisfy AGR-CC(voi) & IDENT(son), AGR-CC(voi) can be violated. Thus, candidate (b) is the optimal candidate. Along this line, the sonorant onset$_{(\sigma2)}$ [n] and [l] are also protected by AGR-CC(voi) & IDENT(son) and they are not devoiced in order to satisfy AGR-CC(voi).

3.2.4 The rime(σ1): Vʔ

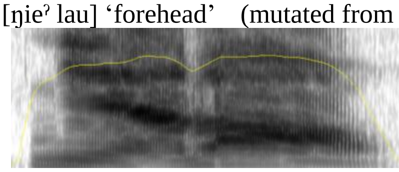
When the rime$_{(\sigma1)}$ is Vʔ, the onset$_{(\sigma2)}$ consonants perform the same mutation patterns as the onset$_{(\sigma2)}$ consonants with the V rime$_{(\sigma1)}$, as summarized by (49).

(49) Consonant mutations (rime $_{(\sigma1)}$: Vʔ)

Rime $_{(\sigma1)}$	Onset $_{(\sigma2)}$	Alternations	Onset $_{(\sigma2)}$	Alternations
Vʔ	p, p^h → [β]	spirantization, voicing	ts, ts^h → [ʒ]	spirantization voicing, palatalization
	t, t^h, s → [l]	lateralization, voicing		
	k, k^h, h → ϕ	deletion	m, n, ŋ, l → --	no change

As previous researches noted, [ʔ] is weakened even dropped when it is followed by other phones (Chen 1990, Feng 1993, among others). Crucially, the spectrogram below also shows that [ʔ] is dropped in the environment.

(50) [ŋieˀ lau] 'forehead' (mutated from [ŋieˀ t^{h}au])



There is no gap between [e] and [l], so the glottal stop is indeed dropped.

Therefore, docking allomorph$_1$ or allomorph$_2$ to the onset$_{(\sigma2)}$ consonants does not produce an illicit consonant cluster, in which the two consonants do not agree in voice. Allomorph$_1$ and allomorph$_2$ can surface. As a result, the onset$_{(\sigma2)}$ consonants with the rime$_{(\sigma1)}$ Vʔ actually have the same mutated patterns as the ones with the rime$_{(\sigma1)}$ V rather than those with the rime$_{(\sigma1)}$ Vk.

3.2.5 Interim conclusion

The autosegmental theory can explain most of the consonant mutations in Fuzhou, as shown by the words with plain form in table (51) below.

(51) Consonant mutations in Fuzhou

Rime $_{(\sigma1)}$	Onset $_{(\sigma2)}$	Rime $_{(\sigma1)}$	Onset $_{(\sigma2)}$
V ϕ Vʔ	p, pʰ → [β]	Vŋ	p, pʰ → [m]
	t, tʰ, s **→ [l]**		t, tʰ, s, l → [n]
	ts, tsʰ → [ʒ]		**ts, tsʰ → [ʒ]**
	k, kʰ, h → ϕ		k, kʰ, h → [ŋ]
	m, n, ŋ, l → --	Vk	--

An abstract morpheme denotes that two adjacent phones are closely composed in morphologically, and the realization of the morpheme is a set of floating features with three allomorphs: {[+cont, +voi], [+son], ϕ} Parsing the morpheme by words needs to satisfy two higher ranked constraints: MAXFLT and NOVACDOC (Wolf 2007), resulting in some interesting consonant mutations. When the rime $_{(\sigma1)}$ is V, [p, pʰ] mutates to [β], [s] mutates to [l] and [m, n, ŋ, l] do not have any alternation. [k] is deleted because it is hard to perceive the contrast of the corresponding mutated form [ɣ] and vowels. If the rime $_{(\sigma1)}$ is Vŋ, the onset$_{(\sigma1)}$ consonants are nasalized. The reason why onset$_{(\sigma1)}$ consonants do not perform the same mutation pattern as onset$_{(\sigma1)}$ consonants with the rime $_{(\sigma1)}$ V is that the mutated forms and Vŋ would form an illicit sequence of nasals and fricatives and penalized by *NC$_{[+cont]}$. In order to satisfy MAXFLT, NOVACDOC and *NC$_{[+cont]}$, onset$_{(\sigma1)}$ consonants change into nasals. As for the rime$_{(\sigma1)}$ Vk, allomorph$_1$ [+voi, +cont] and allomorph$_2$ [+son] cannot surface because GEN produces an illicit consonant cluster without agreeing the voicing and all candidates are ruled out by AGR-CC(voi). Therefore, allomorph$_3$ ϕ is fed to GEN, and parsing ϕ by words does not cause any change. In terms of the rime$_{(\sigma1)}$ Vʔ, since [ʔ] is dropped, the onset$_{(\sigma1)}$ consonants have the same mutation pattern as the rime$_{(\sigma1)}$ V. Although the autosegmental analysis can account for most of the alternations of Fuzhou consonant mutations, the mutations listed by bolded characters are still unsolved (i.e., the mutations of alveolar stops and alveolar affricates). In the following section, I will deal with these exceptions by the dispersion theory (Flemming 2004).

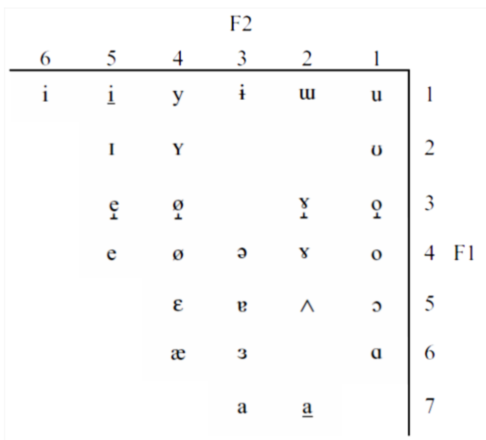
4. Maximizing the contrasts

In this section, I will briefly introduce some background knowledge of the Dispersion Theory (Flemming 2001, 2004). Then, I will adopt this framework to explain the apparent exceptions of Fuzhou consonant mutations.

4.1 The Dispersion Theory

The Dispersion Theory is a functionalist theory of phonology proposed by Flemming (2004). The gist of the theory is that phonology is shaped by the needs of minimizing perceptual difficulties. That is, less confusable contrasts are preferred over more confusable contrasts. Therefore, constraints in this framework are constraints on contrasts. That is, they concern the differences between forms instead of the forms themselves. Adopting the psychological work of Shepard (1957) and Nosofsky (1992), Flemming (2004) suggests that the closer two sounds in the perceptual space are, the more confusable the two sounds are. For example, Flemming explains why languages have [i-u] instead of [ɨ-u] in the vowels inventory by the perceptual space of vowels delimited by formants, as shown by (52).

(52)



F2 scale is ordered by the backness of vowels. The most back one [u] has the lowest score, and the least back one [i] has the most score. Thus, the contrast of [ɨ-u] is less distinct than the contrast of [i-u], so the latter is preferred. This requirement of maximal auditory distinctiveness is indicated by MINDIST=*Dimension : distance*. For example, MINDIST=F2:3 is satisfied by the contrast of two sounds which differ by at least 3 on the F2 dimension. Since the distinctiveness should be maximized, MINDIST=*D:n* is ranked above MINDIST=*D:n*+1 and so on.

Besides, the other significant requirement of constraints on contrasts is to maximize the number of contrasts. This concept is formalized by a positive constraint MAXIMISE CONTRASTS (Flemming 2004), which counts the number of contrasts in the candidate inventory. That is, the larger inventory is, the better the candidate is. Actually, there is a confliction between MINDIST=*D:n* and MAXIMISE CONTRASTS. The former requires the maximal distance of contrasts, which implies the inventory cannot be too large;

the latter contrarily requires the maximal number of contrasts. Therefore, the inventory of a language is determined by the language-specific ranking of the two constraints.

Following the insight of the Dispersion Theory, this paper suggests the mutations of onset$_{(\sigma2)}$ alveolar affricates and alveolar stops are driven by avoiding confusable contrasts.

4.2 Mutations of alveolar stops and affricates with the V rime(σ1)

When the rime$_{(\sigma1)}$ is V or Vʔ, the onset$_{(\sigma2)}$ [t] and [t^h] mutates to [l] but [ts] and [ts^h] mutates to [ʒ], as shown by (6) (repeated as (53)).

(53) Consonant mutations (rime $_{(\sigma1)}$: V, Vʔ)

Rime $_{(\sigma1)}$	Onset $_{(\sigma2)}$	Alternations	Examples
V Vʔ	t, t^h → [l]	voicing lateralization	V 花店 hua taiŋ → hua laiŋ Vʔ 白撞 paʔ tɔuŋ → paˀ lɔuŋ
	ts, ts^h → [ʒ]	voicing spirantization palatalization	V 厝租 ts^{h}uo tsu → ts^{h}uo ʒu Vʔ 落座 loʔ tsɔ → loˀ ʒɔ

However, the autosegmental analysis predicts that the onset$_{(\sigma2)}$ [t], [t^h], [ts] and [ts^h] should mutate to [z], as shown by (31) and (32) (repeated as (54)-(55)). The optimal output is candidate (d) because they satisfy the higher ranked constraints: MAXFLT, NOVACDOC and MPARSE. Unfortunately, this prediction is not consisted with the real output in (53).

In addition to the requirement of docking floating features on a consonant, I suggest that mutations are further conditioned by the need to minimize conceptual confusion (i.e., the Dispersion Theory). Therefore, if the mutated forms of the onset$_{(\sigma2)}$ [t], [t^h], [ts] and [ts^h] are [z], the contrast of alveolar stops and affricates cannot be maintained. These mutation patterns violate MAXIMISE CONTRASTS (Flemming 2004) mentioned above. In order to preserve the contrast of alveolar stops and affricates and satisfy MAXIMISE CONTRASTS, they should mutate to different forms.

(54) 'girl' with allomorph$_1$ [+cont, +voi]

Input: /a [+cont, +voi] + t^{h}au /	MAXFLT	NOVAC DOC	MPAR SE	IDENT (cont)	IDENT (voi)
a. a ~~[+cont]~~ ~~[+voi]~~ t^{h}au	[+cont]! [+voi]				
b. a ~~[+voi]~~ sau [+cont]	[+voi]!			*	
c. a ~~[+cont]~~ dau [+voi]	[+cont]!				*
d. 💣 a zau [+cont] [+voi]				*	*
e. Null Parse			*!		

(55) 'mouse' with allomorph$_1$ [+cont, +voi]

Input: /lo [+cont]$_1$[+voi]$_2$+ ts^hy/ [-cont]$_3$ [+cont]$_4$	MAXFLT	NOVACDOC	MPARSE	IDENT(cont)	IDENT(voi)
a. lo ~~[+cont]$_1$~~ ~~[+voi]$_2$~~ ts^hy [-cont]$_3$ [+cont]$_4$	[+cont]$_1$![+voi]$_2$				
b. lo ~~[+voi]$_2$~~ ts^hy [-cont]$_3$ [+cont]$_{1,4}$	[+voi]$_2$!	[+cont]$_1$!			
c. lo ~~+cont]$_1$~~ dz^hy [-cont]$_3$ [+cont]$_4$ [+voi]$_2$	[+cont]$_1$!				*
d. 💣 lo zy [+cont]$_1$ [+cont]$_4$ [+voi]$_2$				*	*
e. Null Parse			*!		

Then, here come the question. It is unclear why both alveolar stops and affricates mutate to different forms rather than one mutates to other phones but the other still mutates to [z]. The latter mechanism is more economical and should be the preferred option; however, the prediction is not born out. Alveolar stops [t] and [t^h] mutate to [l], but [ts] and [ts^h] mutate to [ʒ]. This paper suggests that the mutations of alveolar stops and affricates are resulted from the requirement of maximizing the auditory distinctiveness among the mutation form of alveolar stops [t, t^h], fricatives [s] and affricates [ts, ts^h] (i.e., satisfying MINDIST=D:n).

The conceptual space of consonants can be quantized by the place of articulation (henceforth PA) and the manner of articulation (henceforth MA), as shown by (56).

(56)

Place of Articulation

Dental 5	Alveolar 4	Post-alveolar 3	Palatal 2	velar 1		Manner of Articulation
	t^h, t			k^h, k	1	stop
	s, z	ʒ			2	fricative
	l				3	lateral

PA dimension is defined by the backness of the place of articulation. The value is increased from velar to dental. MA dimension is defined by the manner of airstream from the oral cavity. The more the airstream flows, the higher the MA score of a consonant is. Thus, the value is increased from stop to lateral. Sounds are specified by the matrices of dimension values. For example, [z] is specified as [PA *4*, MA *4*].

The mutated forms should differ by at least 2 on the dimension of PA and

MA altogether, which is indicated by MINDIST= PLACE & MANNER:2.[13] Please consider the tableau below, where the IDENT-OO family evaluates the correspondence of the mutated forms with floating features and the forms following the requirement of the dispersion.

(57)

	MINDIST= PLACE & MANNER:2	MAXIMISE CONTRASTS	IDENT-OO (place)	IDENT-OO (lat)
a. l-z-z	**!*	✓✓		
b. l-z-ʒ	**!	✓✓✓	*	
c. ☞ l-ʒ-l	*	✓✓	*	*
d. l-ʒ-ʒ	*	✓✓	**!	*

In candidate (a), the distance on PLACE & MANNER between each mutated forms are all less than two. [z] is specified as [PA *4*, MA *4*], and [l] is marked as [PA *4*, MA *3*], so the distance between [z-z] is 0 and the one between [z-l] is 1. There are two pairs of contrast [z-l]. Therefore, candidate (a) is penalization by violating MINDIST= PLACE & MANNER:2 three times. Candidate (b) has more contrasts in the inventory and satisfies MAXIMISE CONTRASTS three time, which is better than other candidates. However, the contrast [z-ʒ] and [z-l] only differ by 1 respectively, so this candidate is ruled out because it violates MINDIST= PLACE & MANNER:2 twice. Candidate (c) and (d) only violate MINDIST= PLACE & MANNER:2 once. Each of the contrast [l-l] in (c) and [ʒ-ʒ] in (d) violates MINDIST= PLACE & MANNER:2 once. Besides, they both have two contrasts in their inventory. Candidate (c) is the optimal candidate because there is only one phone undergoes palatalization, yielding one violation of IDENT-OO (place). However, two phones palatalized in candidate (d), so it is penalized by two violations of IDENT-OO (place).

4.3 Mutations of alveolar affricates with the Vŋ rime(σ1)

Alveolar affricates mutate to [ʒ] when the rime$_{(\sigma 1)}$ is Vŋ, as shown by (7) (repeated as (58) below).

[13] The anonymous reviewer mentioned that the constraint MINDIST= PLACE & MANNER: 2 and the number set in (56) are arbitrary and they may not be able to be extended to other languages. I admit that the setting in (56) is somehow arbitrary. It is just a tool to formalize the distinctions of place of articulation and manner of articulation. More phonetic experiments are needed to justify or modify this setting. Nevertheless, if we assume a conceptual space of consonants and the constraint MINDIST=D:n, the mutation in Fuzhou and even mutations other languages can be explained. As Fleming (2004) suggests, different inventories of vowels and consonants in different languages are resulted from the different values of *dimension* and *distance* of the constraint MINDIST=*Dimension: distance*. Following the same line, it is not totally implausible to suggest that the *Dimension* and *distance* of consonants in Fuzhou, though somehow technical, are set as PLACE & MANNER and 2, respectively. If other languages perform different types of mutations, the *Dimension* and *distance* may be set as different values according to the data observed in that language.

(58) Consonant mutations (rime $_{(\sigma1)}$: Vŋ)

Rime $_{(\sigma1)}$	Onset $_{(\sigma2)}$	Alternations	Examples
Vŋ	ts, tsʰ → [ʒ]	voicing spirantization palatalization	簽字 tsʰieŋ tsɛi → tsʰieŋ ʒɛi 青草 tsʰaŋ tsʰau → tsʰaŋ ʒau

However, the pure autosegmental analysis predicts that alveolar affricates should mutate to [n], as demonstrated by (45) (repeated as (59)).

(59) 'sign' with allomorph$_2$ [+son] (take 2)

Input: /tsʰieŋ [+son] + tsɛi /	*NC$_{[+cont]}$	MAXFLT	NOVACDOC	MPARSE	IDENT (son)
a. tsʰieŋ ~~[+son]~~ tsɛi		[+son]!			
b. tsʰieŋ lɛi [+son]	*!				*
c. 💣 tsʰieŋ nɛi [+son]					*
d. Null Parse				*!	

Following the same line proposed by section 4.2, this phenomenon can be solved by the dispersion theory. That is, [ts] mutates to [ʒ] rather than [n] to satisfy MINDIST= PLACE & MANNER:2. Please see the tableau below.

(60)

	MINDIST= PLACE & MANNER:2	*NC $_{[+cont]}$	MAXIMISE CONTRASTS	IDENT-OO (place)	IDENT-OO (nas)
a. n-n-n	**!*		✓		
b. n-n-ɲ	**!*		✓✓	*	
c. ☞ n-n-ʒ	*	*	✓✓	*	*
d. l-n-n	**!*	*	✓✓		*
e. l-n-ɲ	**!	*	✓✓✓	*	*
f. l-n-ʒ	*	**!	✓✓✓	*	**

Candidate (a), (b), (d) and (e) are ruled out because they violate MINDIST= PLACE & MANNER:2 more than once. In candidate (c), only the contrast [n-n] violates MINDIST= PLACE & MANNER:2. The other contrasts [l-n] satisfy this undominated constraint. Candidate (f) also violates MINDIST= PLACE & MANNER:2 once. Only the contrast [l-n] does not differ by 2 on the dimension of PA and MA. Although candidate (f) has more contrasts than candidate (c), the former violates *NC $_{[+cont]}$ twice but the latter violates the constraint once. Given that *NC $_{[+cont]}$ dominates MAXIMISE CONTRASTS, candidate (c) is the optimal candidate.

The apparent exceptions of the pure autosegmental analysis can be explained by the dispersion theory. Therefore, the complicated Fuzhou mutations suggest an analysis combining the autosegmental theory and dispersion theory.

5. Conclusion

This paper provides a synchronic analysis of consonant mutations in *Fuzhou*, which presents the following special properties. First, it is onset$_{(\sigma 2)}$ consonants that undergo consonant mutations instead of the coda contained in rime $_{(\sigma 1)}$. Second, the type of rime $_{(\sigma 1)}$ determines the kind of the consonant mutations. Third, consonant mutations apply even though there is actually no correspondent feature in the triggering environment. Fourth, different onsets$_{(\sigma 2)}$ undergo different phonological processes in the same environment. Along the line of the Autosegmental Theory (Wolf 2007), this paper suggests that the main driving force of mutations is an abstract morpheme whose realization is a set of floating features. The abstract morpheme denotes that the two phones in sequence are tightly combined with each other, so the morpheme has morphological and even semantic functions. However, the pure autosegmetal analysis fails to explain the mutations of alveolar stops and affricates with the V rime$_{(\sigma 1)}$, Vʔ rime$_{(\sigma 1)}$ and Vŋ rime$_{(\sigma 1)}$. These apparent exceptions can be solved by the Dispersion Theory (Flemming 2004), which emphasizes the need of minimizing perceptual confusion. Combining the Autosegmental Theory, the Dispersion Theory and other markedness constraints, this paper can answer the following problems raised by Fuzhou consonant mutations: (i) the motivation of mutation, (ii) the role of the type of rime$_{(\sigma 1)}$, and (iii) the systematic phonological processes applied on onset$_{(\sigma 2)}$ consonants. Consonant mutations in *Fuzhou* suggest that both formal theories (i.e., the Autosegmental Theory) and functionalist theory (the Dispersion Theory) are equally important in Phonology.

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