Zhangzhou Implosives and Their Variations

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Abstract

As a typologically rare phenomenon, the airstream mechanism of glottalic ingressive is employed phonemically in Zhangzhou Southern Min, a Sinitic dialect spoken in Southern China. Their realisations are observed to be highly diverse, with 11 phonetic variants ([ɓ, ɗ, ɠ, m, n, ŋ, β, lʷ, ɣʷ, g̰, ɠʲ]) that can be derived from 3 implosives (/ɓ, ɗ, ɠ/). Such dynamic allophonic variation occurs as a consequence of regressive impacts from subsequent nasal [Ṽ], labial-velar [u, w], and palatal [i, j] segments. Several phonetic processes can be generalized, comprising labialisation, nasalisation, lenition, laminalisation, dentalisation and palatalization, which trigger alternation on the airstream mechanism, change the manner of articulation or place of articulation, and result in diverse outputs that can be characterized using phonological rules. This study directly strengthens our understanding of the phonology and phonetics of implosives in this dialect while contributing convincing empirical data to the typology of phonation as a special linguistic phenomenon in natural languages. It also sheds important light on how human languages can be encoded in a complicated way far beyond our general assumptions and expectation.

Keywords: Implosives, allophonic variation, phonological rule, Zhangzhou

1 Introduction

Human languages exploit various dimensions to characterise consonants, which comprise place of articulation, manner of articulation, nasality, laterality, phonation, voicing status of the glottis, aspiration, and airstream mechanism, among others (Bickford & Floyd, 2006). Each dimension can further classify consonants into several different sub-categories. For example, the airstream mechanism can group consonants into pulmonic egressive, glottalic egressive (ejective), glottalic ingressive (implosive), and velaric ingressive (click), which are lexically observed around the world, depending on where the airstream is initiated, lungs, glottis, or tongue, and in which direction the airstream flows, outward or inward (Bickford & Floyd, 2006).

The Sinitic dialect of Zhangzhou Southern Min, spoken in the South Fujian province of Mainland China, is found to employ two types of airstream mechanisms in its consonantal system. In addition to the general type of pulmonic egressive, three implosive sounds (/ɓ, ɗ, ɠ/) are synchronically used to distinguish lexical items However, it may be because of their special mechanism that is only found in 13% of the world's languages, and the continuous motion of organ apparatus in speech production, the realisations of implosive phonemes are observed to be highly diverse, with eleven variants being derived at the surface level, covering five different places of articulation, and four types of the manner of articulation, as shown in Table 1.

Onset	Labial	Dental	Alveolar	Palatal -velar	Velar
Implosive	[ɓ]	[ɠ]	[ɗ]	[ʛ]	[ɠ]
Nasal	[m]		[n]		[ŋ]
Fricative	[β]				[ɣʷ]
Lateral			[lʷ]		

Table 1: Phonetic variants of Zhangzhou implosives

Such an intriguing linguistic phenomenon has not received any attention in the literature until Huang (2018; 2019; 2020) firstly documented the existence of implosives in this dialect. As an extension to explore their nature, this article is designed to systematically explore and discuss the phonology and phonetic variation of implosives in Zhangzhou Southern Min. It aims to address three research questions (a) what has motivated such diverse allophonic variation of implosives; (b) how these phonetic outputs can be derived from their underlying representation, and (c) how the observed variation can be interpreted using the distinctive feature theory. It is hoped to broaden and deepen our knowledge of implosives and their variation in this Southern Min variety, while contributing important empirical data to the typology of the airstream mechanism and sound changes in the world's languages.

2 Zhangzhou and Syllables

2.1 Zhangzhou Speech

Zhangzhou is a prefecture-level city in the south of Fujian province in South-eastern China, covering an area of approximately 12,600 square kilometers and a registered population of about 5.10 million (Huang, 2018). The colloquial language spoken by native speakers is Southern Min, known as Hokkienese. It is mutually intelligible with other Southern Min varieties of Xiamen, Quanzhou and Taiwan, but is entirely unintelligible with other Chinese dialects, such as Mandarin, Hakka, and Cantonese. Because a certain degree of regional variation can be perceived in the sound system among its eleven administrative areas, this study specifies the locality on the urban districts of Longwen and Xiangcheng that are conventionally considered to be representative of Zhangzhou speech (e.g., Ma, 1994; ZZG, 1999).

2.2 Zhangzhou Syllables

A template of C(G)V(X) can be generalised from the synchronic data of Zhangzhou speech in which onset and nucleus are compulsory while glide and coda are optional to occur in a syllable (Huang 2019; 2020). Table 2 summarises the phoneme inventory for individual syllable components. As indicated, Zhangzhou possesses a relatively small onset inventory of 15 phonemes, but their contrasts involve various places of articulation (labial, alveolar, velar, pharyngal and glottal) and manners of articulation (aspiration, voicing, fricative, airstream mechanism). The components of the nucleus system are diverse comprising oral vowels, nasal vowels, and syllabic nasals. Prevocalic glides occupy an independent status, whereas, because of their being less productive, postvocalic glides are grouped into one type of syllable codas that incorporate obstruent and nasal stops. Four syllable types—CV, CGV, CVC, and CGVC—can be generalised as illustrated in Table 3 in which lexical tones are transcribed using Chao (1930)'s notational system with 5 representing the highest pitch level and 1 the lowest.

Component		**Phoneme**
Onset	C	p, pʰ, ɓ, t, tʰ, ɗ, k, kʰ, ɠ, ts, tsʰ, s, z, ɦ, ʔ
Glide	G	j, w
Nucleus	V	i, e, ɛ, ɐ, ɔ, ɵ, u, ĩ, ɛ̃, ɐ̃, ɔ̃, m̩, ŋ̩
Coda	X	j, w, m, n, ŋ, p, t, k

Table 2. Phoneme inventory for Zhangzhou syllables

Syllable	**Example 1**	**Example 2**
CV	/ʔɔ35/ 'dark'	/dĩ22/ 'year'
CGV	/sjɐ51/ 'write'	/kwɐ35/ 'song'
CVC	/sim35/ 'heart'	/kɐw22/ 'monkey'
CGVC	/kwɐj35/ 'obedient'	/tsjɐp41/ 'juice'

Table 3. Examples of syllable types in Zhangzhou

3 Zhangzhou Implosives

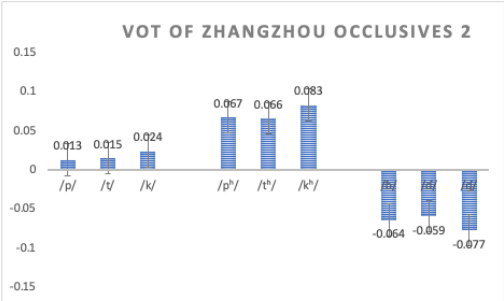
3.1 Zhangzhou Plosives

As many as 60% of Zhangzhou onset phonemes are oral plosives, which can be characterised in several different ways. They can be classified into bilabial (/p, pʰ, ɓ/), alveolar (/t, tʰ, ɗ/), and velar plosives (/k, kʰ, ɠ/) in accordance with where the oral constriction is created. Among those onsets sharing an identical place of articulation, a neat three-way contrast comprising voiceless aspirated (/pʰ, tʰ, kʰ/), voiceless unaspirated (/p, t, k/), and voiced plosives (/ɓ, ɗ, ɠ/) can be identified. Similarly, the onsets can be grouped into pulmonic egressives (/p, pʰ, t, tʰ, k, kʰ/) and glottalic ingressives (/ɓ, ɗ, ɠ/) (known as implosives) with respect to where and in which direction the

airstream is initiated in the vocal tract. Table 4 illustrates the nine oral plosives in this dialect.

Table 4. Examples of Zhangzhou oral plosives

Onset		Example 1	Example 2
Labial	/p/	/pi51/ 'compare'	/piŋ22/ 'friend'
	/pʰ/	/pʰi51/ 'scab'	/pʰiŋ22/ 'comment'
	/ɓ/	/ɓi51/ 'rice'	/ɓiŋ22/ 'bright'
Alveolar	/t/	/ti51/ 'resist'	/tiŋ22/ 'pavilion'
	/tʰ/	/tʰi51/ 'store'	/tʰiŋ22/ 'stop'
	/ɗ/	/ɗi51/ 'you'	/ɗiŋ22/ 'zero'
Velar	/k/	/ki51/ 'point	/kiŋ22/ 'lift up'
	/kʰ/	/kʰi51/ 'tooth'	/kʰiŋ22/ 'jade'
	/ɠ/	/ɠi51/ 'speech'	/ɠiŋ22/ 'welcome'



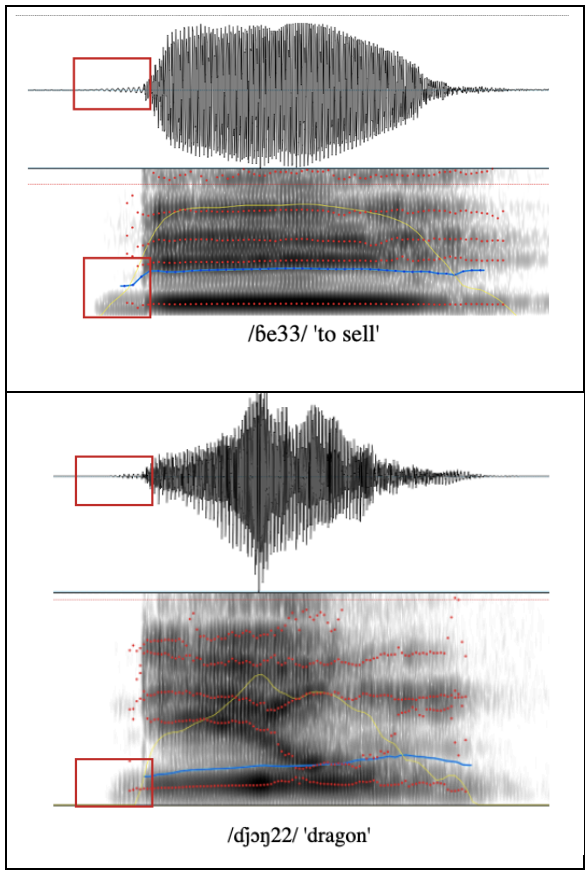
The plosives can also be well distinguished in terms of the phonetic parameter of VOT (voice onset time), which is defined as the time between the release of an oral constriction for the plosive production and the onset of vocal fold vibration to produce vocalic segment (Abramson & Whalen 2017). This can be seen in Figure 1, which is derived from quantifying 1147 samples (=6 tokens * 9 plosives * 21 speakers) based on the empirical data that the first author collected in the urban districts of Zhangzhou city in 2015.

Figure 1: VOT distribution of Zhangzhou plosives.

As shown, the voiceless unaspirated plosives (/p/, /t/, /k/) consistently show positive values slightly above zero from 0.013 ms to 0.024 ms, because the vocal folds vibrate for subsequent vowel/glide production immediately after the oral constriction is released. The voiceless aspirated stops (/pʰ, tʰ, kʰ/) show steep positive values from 0.067 ms to 0.083 ms because, after the plosive releases, there is a period for the articulation of aspiration, causing a delay in the onset of vocal fold vibration. Contrastively, those implosives (/ɓ, ɗ, ɠ/) present steep negative values between -0.077 ms and -0.064 ms because the vocal folds start vibrating before the oral constriction is released.

3.2 Comparison with Prior Work

Zhangzhou has received extensive documentation on its segmental system, but all prior works (Dong 1959; Lin 1992; Ma 1994; FJG 1998; ZZG 1999) do not document any implosive sound until Huang's preliminary finding (2018; 2019; 2020) start using such a concept. Instead, the three implosive sounds /ɓ, ɗ, ɠ/ are conventionally documented as /b, l, g/, which appears not to be supported in synchronic data. All auditory impressions and acoustic manifestations, along with the observation of the articulatory gesture of native speakers in the field site, show that related tokens are seldom pronounced with voiced pulmonic plosives [b] and [g], though the alveolar lateral [l] can be perceived on a certain occasion as an allophonic variant of alveolar implosive /ɗ/, which will be discussed in a later section. Figure 2 illustrates the waveforms and spectrograms of three implosives of different places of articulation from a 58-year-old male speaker WYF.



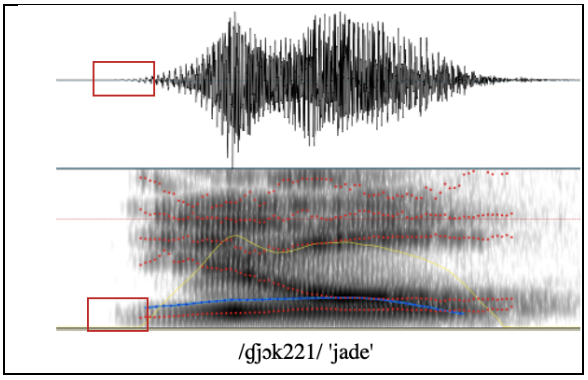


Figure 2: Spectrograms and waveforms of implosives in Zhangzhou Southern Min (WYF, male).

As seen, a voice bar can be seen at the bottom of each spectrogram of the three examples, signifying the vibration of vocal folds before the production of subsequent vocalic segments. As well as this, the amplitude of waveforms gradually increases from the beginning of the voicing till the oral release, indicating a glottalic ingressive mechanism. This is because, during the articulation, the larynx is lowered, causing the supra-laryngeal cavity to be enlarged while the oral closure is maintained. A growing amplitude of waveform has been cross-linguistically reported to be a typical indicator for implosive sounds, such as in Bantu (Velde et al. 2019), and Chaozhou Chinese (Cun, 2010).

4 Allophonic Variation of Implosives

While having a relatively small size of onset inventory, the realizations of individual phonemes in Zhangzhou are found to be diverse, motivated by various factors, resulting in several variants at the surface level. For example, as indicated in Figure 3, the bilabial implosive /ɓ/ is weakened to a voiced bilabial fricative [β] when it precedes the rounded back vowel [u], shifted to the labial nasal [m] before nasal vowels, while realized as an implosive [ɓ] elsewhere. Similarly, the alveolar implosive /ɗ/ is found to have four variants of [ɖ̪, lʷ, n, ɗ], while the velar implosive /ɠ/ is realised differently with four variants of [ɠʲ, ɣʷ, ŋ, ɠ].

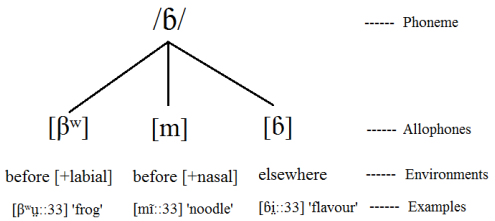


Figure 3: Allophonic variants of labial implosive /ɓ/.

Though phonetically very different, the variants of the implosive phonemes are in complementary distribution, and their occurrences are predictably conditioned by three main factors comprising the palatal [i] and[j], the bilabial ([u]), and the nasality feature of nasal vowels [Ṽ], as summarized in Table 5. This section is to discuss how eleven allophones are derived from only three implosives and what has motivated such a rich variation.

Impl.	/_[i, j]	/_[u, w]	/_[Ṽ]	Elsewhere
/ɓ/	[ɓ]	[β]	[m]	[ɓ]
/ɗ/	[ɖ̪]	[lʷ]	[n]	[ɗ]
/ɠ/	[ɠʲ]	[ɣʷ]	[ŋ]	[ɠ]

Table 5. Allophonic variants of Zhangzhou implosives.

4.1 Nasal-Conditioned Variation

Contrastive nasal consonants are absent in the onset inventory of Zhangzhou speech, but they are perceivable in certain circumstances. The three implosives /ɓ/, /ɗ/, and /ɠ/ are found to be realised as their corresponding homorganic nasal plosives [m], [n], and [ŋ], respectively, before nasal vowels. As illustrated in Table 6, the bilabial and alveolar implosives are underlyingly able to combine with all nasal vowels that can be identified in the data. On the contrary, the volar implosive can only occur before /ɛ̃/ and /ɔ̃/, since there present phonological gaps in its combination with nasal vowels /ɐ̃/ and /ĩ/ to form attested syllables.

Implosive		Phonemic	Phonetic	Gloss
/ɓ/	[m]	/ɓɛ̃33/	[mɛ̃33]	'scold'
		/ɓɔ̃35/	[mɔ̃35]	'crazy'
		/ɓĩ33/	[mĩ33]	'noodle'
		/ɓɐ̃35/	[mɐ̃35]	'mum'
/ɗ/	[n]	/ɗɛ̃35/	[nɛ̃35]	'milk'
		/ɗɔ̃33/	[nɔ̃33]	'two'
		/ɗĩ33/	[nĩ33]	'dye'
		/ɗɐ̃22/	[nɐ̃22]	'forest'
/ɠ/	[ŋ]	/ɠɛ̃33/	[ŋɛ̃33]	'stiff'
		/ɠɔ̃51/	[ŋɔ̃51]	'midday'

Table 6. Examples of nasal-conditioned variation

As seen, the derivation from implosives (/ɓ, ɗ, ɠ/) to nasal stops ([m, n, ŋ]) involves changing the airstream mechanism from glottalic ingressive to pulmonic egressive and also changing the manner of articulation from oral plosives to nasal plosives. Such an alternation can be interpreted as an effect of nasalization motivated by the [+nasality] feature of nasal vowels, which is understandable from the articulatory perspective. The articulation of nasal vowels requests a lowered velum to partially block

the airstream passing through the oral cavity, which contradicts the articulatory setting for implosive production. Because during the articulation of implosive sounds, the velum has to be raised to completely block off the nasal cavity, whereby the airstream can rush into the mouth before they flow out again to release the oral constriction (Bickford & Floyd, 2006). Thus, for maximum ease of articulation, it appears to be a natural process for implosives to be pronounced as nasal sounds as an impact of the progressive assimilation to their subsequent nasal vowels. This nasalisation can thus be expressed using the rule in (1).

Rule (1). Nasalisation of implosives /ɓ, ɗ̠, ɠ̠/

$$/ɓ,\ ɗ̠,\ ɠ̠/ \rightarrow [m,\ n,\ ŋ]/\_\ \mathbf{[\tilde{V}]}$$

$$\begin{bmatrix}+\text{glottalic}\\+\text{ingressive}\\+\text{voice}\end{bmatrix} \longrightarrow \begin{bmatrix}+\text{nasal}\\-\text{ingressive}\\+\text{pulmonic}\end{bmatrix} \Big/ \underline{\quad} \begin{bmatrix}+\text{nasal}\\+\text{vocalic}\\+\text{pulmonic}\\-\text{consonantal}\end{bmatrix}$$

4.2 Labial Velar-Conditioned Variation

The realisation of implosive phonemes undergoes substantial changes when they proceed segments of either nucleus or prevocalic glide that feature [+labial] and [+velar]. The bilabial implosive /ɓ/ is realised as its homorganic voiced fricative [β]; the velar one /ɠ̠/ becomes a voiced labialized velar fricative [ɣʷ]; the alveolar implosive /ɗ̠/ is observed to change to a labialized lateral approximant [lʷ], as illustrated in Table 7.

Implosive		Phonemic	Phonetic	Gloss
/ɓ/	[β]	/ɓu51/	[βu51]	'dance'
		/ɓu33/	[βu33]	'frog'
		/ɓwi35/	[βwi35]	'smile'
		/ɓwɐ22/	[βwɐ22]	'grind'
/ɗ̠/	[lʷ]	/ɗu51/	[lʷu51]	'female'
		/ɗu35/	[lʷu35]	'push'
		/ɗwi35/	[lʷwi35]	'money'
		/ɗwɐ22/	[lʷwɐ22]	'spicy'
/ɠ̠/	[ɣʷ]	/ɠu22/	[ɣʷu22]	'cow'
		/ɠu33/	[ɣʷu33]	'giggle'
		/ɠwɐ51/	[ɣʷwɐ51]	'I'
		/ɠwe22/	[ɣʷwe22]	'moon'

Table 7. Examples of labial-velar-conditioned variation

As seen, the peripheral implosives /ɓ/ and /ɠ̠/ both involve changing the airstream mechanism from the glottalic ingressive to pulmonic egressive and also changing the manner of articulation from plosive to fricative, while the latter acquires an additional feature [+labial] from its subsequent rounded segment as the output. The derivation can be considered resulting from the effect of the sonorising lenition process. Because of a reduced articulatory effort during the production, the features of the glottalic ingressive airstream mechanism and the complete oral constriction for implosive sounds are deleted, resulting in more sonorant fricatives but with the same place of articulation that can be captured in this labial-velar context. The lenition process can also be referred to as spirantization (Gurevich, 2011).

On the contrary, the alveolar implosive /ɗ̠/ is not realized as a fricative as its counterparts in different places of articulation, but rather, it is observed to change to a lateral approximant [lʷ] before the labial-velar segments /u/ and /w/, which may be ascribed to two reasons. There already exists a voiced alveolar fricative phoneme /z/ in this dialect. Thus, the phonological awareness of native speakers may make it not to be a premium option to be realized. Another plausible reason may be that, the two voiceless alveolar plosives /t/ and /tʰ/ are perceived being laminalised and labialized over their articulation, because native speakers tend to use their tongue blade, rather than the tongue tip, to create a constriction around the alveolar ridge, as illustrated in Table 8. Thus, it is reasonable to assume that the /ɗ̠/ phoneme also receives a process of laminalisation. Correspondingly, the derivation from an alveolar implosive /ɗ̠/ to a labialised lateral approximant [lʷ] could be regarded as a consequence of the coupling effect of lenition, laminalisation and labialization, resulting in the derived sound being more sonorant with a little oral constriction that can be observed in the speaker's articulatory gesture.

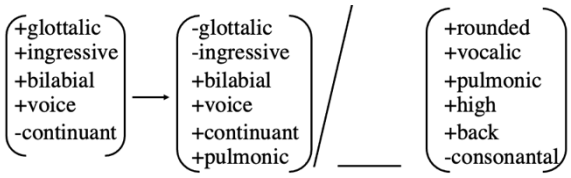
Alveolar		Phonemic	Phonetic	Gloss
/t/	[t̪ʷ]	/tu35/	[t̪ʷu35]	'pile'
		/twɐ33/	[t̪ʷwɐ33]	'big'
/tʰ/	[t̪ʰʷ]	/tʰu41/	[t̪ʰʷu41]	'dispute'
		/tʰwɐ35/	[t̪ʰʷwɐ35]	'drag'

Table 8. Examples of laminalisation of alveolar plosives

Thus, because of different places of articulation, the three implosives involve different phonetic processes for their realisation in the labial-velar environment, though they share a commonness of changing the airstream mechanism from the glottalic ingressive to the pulmonic egressive. The deviations can also be captured in terms of rules, as expressed in Rule (2)-(4) below.

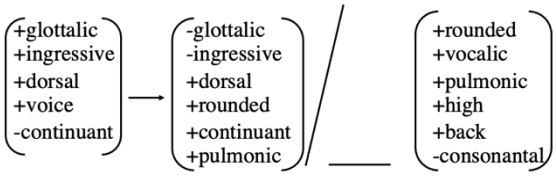
Rule 2: Lenition process of /ɓ/

/ɓ/ → [β]/_ [u; w]



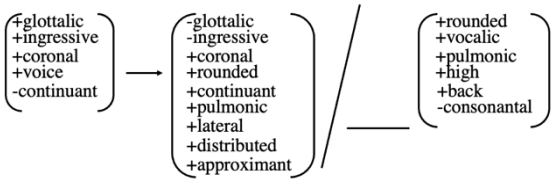
Rule 3: Lenition and labialization of /ɠ/

/ɠ/ → [ɣʷ]/_ [u; w]



Rule 4: Lenition, laminalization and labialization of /ɗ/

/ɗ/ → [lʷ]/_ [u; w]



4.3 Palatal-Conditioned Variation

The palatal segments of vowel [i] and glide [j] can also form a palatal environment of [+high, +front, +sonorant] and trigger processes on implosives to have different realizations. The alveolar implosive /ɗ/ is found to be dentalised and becomes [ɗ̪] when it occurs before the segments [i] and [j]. This is observed based on the articulatory gesture of native speaker during the production, whose tongue tip appears not to raise to the alveolar ridge but rather touch the back of the upper incisor to create a constriction. On the contrary, the velar implosive /ɠ/ is palatalized and becomes a fronted sound [ɠʲ]. This velar fronting is predictably natural to occur because of progressive assimilation to the high and front properties of subsequent segments, native speakers are observed moving their tongue forward the hard palate to form a constriction. On the contrary, the bilabial implosive /ɓ/ does not change their realization in this palatal context. This may be ascribed to the fact that, its primary constriction for is created by lips, out of the oral cavity, rendering its place of articulation not easy to be affected.

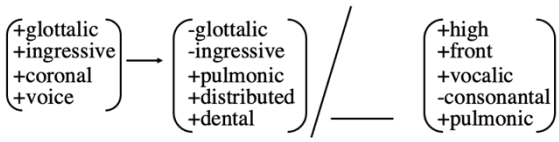
As seen, unlike other conditioning factors as mentioned above, the two palatal segments do not cause a change in both the airstream mechanism and manner of articulation of related implosives; instead, they only affect the place of articulation of those implosives that are non-bilabial, as illustrated in Table 9. The derivation between /ɗ/ and [ɗ̪] can be stated as being triggered by the process of dentalisation, while the derivation between /ɠ/ and [ɠʲ] is motivated by the process of palatalization or velar fronting. They can be, respectively, expressed using the rules (5) and (6).

Implosive		Phonemic	Phonetic	Gloss
/ɗ/	[ɗ̪]	/ɗi51/	[ɗ̪i51]	'you'
		/ɗɟɐ21/	[ɗ̪ɟɐ21]	'catch'
/ɠ/	[ɠʲ]	/ɠi51/	[ɠʲi51]	'speech'
		/ɠɟɐ22/	[ɠʲɟɐ22]	'carry'

Table 9. Examples of palatal-conditioned variation

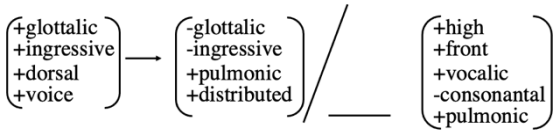
Rule 5: Dentalisation process of /ɗ/

/ɗ/ → [ɗ̪]/_ [i; j]



Rule 6: Palatalisation process of /ɠ/

/ɠ/ → [ɠʲ]/_ [i; j]

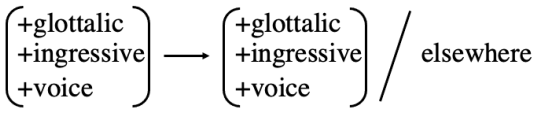


4.4 Elsewhere

The implosives can also occur before the other five non-high oral vowels /e, ɵ, ɛ, ɐ, ɔ/, but are found to be realised as themselves with a glottalic suction initiation, which are thus referred to as unmarked forms. For the bilabial implosive, it is also realised as itself before the palatal segments /i/ and /j/. Examples for the unmarked realization of Zhangzhou implosives are provided in Table 10. Correspondingly, the derivation of implosives in the unmarked environment can also be expressed in rule, as shown in Rule 7.

Rule 7: the unmarked realization of /ɓ, ɗ, ɠ/

/ɓ, ɗ, ɠ/ → [ɓ, ɗ, ɠ]/_elsewhere



Implosive		Phonemic	Phonetic	Gloss
/ɓ/	[ɓ]	/ɓe33/	[ɓe33]	'sell'
		/ɓʊ41/	[ɓʊ41]	'meat'
		/ɓɛ51/	[ɓɛ51]	'horse'
		/ɓɵ22/	[ɓɵ22]	'do not'
		/ɓɔ51/	[ɓɔ51]	'wife'
		/ɓi51/	[ɓi51]	'rice'
		/ɓjʊt221/	[ɓjʊt221]	'extinguish'
/ɗ/	[ɗ]	/ɗɛ22/	[ɗɛ22]	'snail'
		/ɗʊ33/	[ɗʊ33]	'stir'
		/ɗɛ33/	[ɗɛ33]	'catch'
		/ɗɵ41/	[ɗɵ41]	'high'
		/ɗɔ33/	[ɗɔ33]	'road'
/ɠ/	[ɠ]	/ɠɛ33/	[ɠɛ33]	'skill'
		/ɠʊk221/	[ɠʊk221]	'music'
		/ɠɛ22/	[ɠɛ22]	'teeth'
		/ɠɵ22/	[ɠɵ22]	'goose'
		/ɠɔ33/	[ɠɔ33]	'five'

Table 10. Examples of unmarked implosive realisation

5 Conclusion

As discussed, Zhangzhou Southern Min employs the airstream mechanism of glottalic ingressive as a contrastive feature in its onset system; but their realisations are highly diverse with eleven phonetic variants that can be derived from three implosive phonemes. The allophonic variation presents regular and predictable patterns under the regressive assimilatory influence of three factors comprising the nasal [**Ṽ**], labial-velar [u, w], and palatal [i, j] characteristics of subsequent segments. The nasal factor alters the airstream mechanism from glottalic ingressives to pulmonic egressives and changes the manner of articulation to be nasal. The labial-velar factor affects the implosives at different extents depending on their place of articulation. It triggers a lenition process on the bilabial implosive, coupling processes of lenition and labialization on the velar implosive but induces more complex effects on the alveolar implosive involving labialization, laminalisation and lenition. The two non-alveolar implosives are thus changed to their homorganic voiced fricative counterparts, while the alveolar implosive is changed to a lateral approximant. The palatal factor shifts the place of articulation of the two non-labial implosives under the influence of dentalisation or palatalization.

The diverse allophonic variation of implosives in Zhangzhou Southern Min reflects continuous motions of vocal apparatus in the production of human speech sounds, which causes considerable overlapping in articulatory gestures and leads to dynamic physical outputs to individual phonemes (Anderson, 1978; Ohala, 1993). The discussion of this article directly broadens our understanding of the phonetics and phonology of implosives in this dialect, while demonstrating how diverse factors alter their phonetic outputs in terms of airstream mechanism, place of articulation, and manner of articulation. It is hoped to contribute valuable empirical data to the typology of implosives as a special language phenomenon and shed important light on the typology of sound changes that are synchronically motivated.

6 Reference

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