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Backness Agreement in Consonant + Glide Onsets: Evidence from Mandarin

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This paper extends Duanmu's (2000; 2007) analysis of Mandarin consonant–glide (C^G) onsets by arguing that articulator dissimilation alone cannot account for the full range of grammatical and ungrammatical onset clusters. While Duanmu's *Articulator Dissimilation* (2007: 28–30) principle explains the ban on Labial + Labial sequences (e.g., *[f^w]), it fails to account for illicit clusters like *[f^j], where no articulator overlap exists. This study proposes that both *C^G-Lab^{Lab} and backness agreement constraints are required. Specifically, constraints such as Agree[back]:Dor^G, Agree[back]:$C_{[-son, +cont]}{}^j$, and Agree[back]:$C_{[-son]}{}^u$ better explain the distribution of C^G onsets. Mandarin phonotactics reflect both OCP effects and anti-OCP agreement patterns for ease of articulation and phonetic distinctiveness. I also investigate the classification of the front glides as Coronal versus Dorsal and demonstrate that this distinction does not alter the requirement for backness agreement, suggesting that both major articulator features and dependent features like [back] are essential to a unified analysis of C^G onset constraints in Mandarin.

The present analysis takes a novel approach by combining the Optimality Theory with the sonority scale to better account for the missing C^G combinations and the asymmetry of obstruent patterns in Mandarin onsets. Additionally, glide asymmetry is observed: [ɥ] is distributionally scarce and more restricted. Such markedness scale and sonority scale within complex onsets are also found in other Chinese varieties, including Lanzhou, Fuyang and Putian. These findings suggest broader cross-linguistic applicability and shed light on the phonological principles governing onsets across languages.

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1 Introduction

Xu (2025: 27) argues that, given speech is a highly complex motor activity, the syllable serves as a crucial organizational unit that reduces temporal degrees of freedom (DOF) by synchronizing consonantal, vocalic, and laryngeal gestures—thereby enabling human speech. The cross-linguistic preference for syllables to have onsets further highlights the fundamental role of the onset within the syllabic structure. This raises an important question: how do discrete segments within onsets interact to reduce DOF while still maintaining phonological contrast? The present study investigates the constraints governing onsets in Mandarin and aims to provide insights that extend beyond Mandarin to broader phonological theory.

Some linguists have studied restrictions on onsets by focusing on articulator features: Kochetov (2016: 19) uses the articulator features Lab, Cor, Dor, and Lar in Kirundi CG constraints, and Duanmu (2000: 32; 2007) studies Mandarin onsets using three articulator features: Lab, Cor, Dor. Generative phonologists (Cheng 1973; Lin 1989; Duanmu 1990; 2007; 2008) maintain that a Chinese syllable takes on the format (C) (G) V (X). In other words, a first onset consonant, a glide, a nuclear vowel and a coda consonant or an offglide coda together make up a maximum Chinese syllable. The inventories of Mandarin consonants and vowels are illustrated in detail in Section 2. Duanmu (2000: 32; 2007: 28–30) argues that restrictions on Mandarin consonant plus glide onsets can be accounted for by the *Articulator Dissimilation* principle: "Identical articulators cannot occur in succession." Similar to Duanmu's (2000; 2007) *Articulator Dissimilation account,* Yip (2003: 790–791) proposes that illicit onsets involve segments that are highly similar; conversely, the less similar the segment pair, the more acceptable the onset becomes, in line with the Obligatory Contour Principle (OCP). Gong, Zhang and Fiorentino (2024: 676) also argue that OCP-based constraints play a crucial role in shaping Mandarin speakers' phonological knowledge.

Yet, the OCP-driven *Articulator Dissimilation* (Duanmu, 2007: 28–30) approach does not fully account for all onset data. For instance, Mandarin onsets like [fʲ] are missing even though the initial consonant [f] and the following glide [j] have different articulators. What constraints penalize [fʲ] in Mandarin? Another problem with Duanmu's analysis (2000; 2007) is that the Palatal + Glide combinations are not included in Mandarin onsets. The palatals carry both Dorsal and Coronal articulator features, which obscures the reasons behind the onsets [tɕʲ, tɕʰʲ, ɕʲ, tɕᵘ, tɕʰᵘ, ɕᵘ] and missing ones *[tɕʷ, tɕʰʷ, ɕʷ].

This paper is an extension of Duanmu's investigation into C^G onsets in Mandarin. I show that all Mandarin C^G onset data can be explained by two general principles: (a) No Lab + Lab onsets, as predicted by Duanmu's *Articulator Dissimilation* (2007: 28–30); (b) Backness agreement constraints account for the other C^G clusters. I argue that both OCP (*C^G-Lab^{Lab}) and anti-OCP (backness agreement) constraints are needed to account for the grammaticality of Mandarin

onsets. More specifically, the asymmetry among obstruents with respect to backness agreement indicates that, even in a language with scarce consonant clusters like Mandarin, sonority distance (SD) remains a significant factor in shaping phonological restrictions. In addition, compared to [j] and [w], the glide [ɥ] is cross-linguistically highly marked, which results in all non-palatal obstruent + [ɥ] sequences being penalized.

1.1 Overview

Some languages, like Korean, allow any CG combinations, while other languages, like Kirundi, avoid all CG sequences.[1] Most languages have restrictions on their CG onsets. For example, Italian disallows palatals preceding [j] and [w]; American English disallows coronals followed by the palatal glide [j]; Cantonese avoids the onset [fj] with only a few loanword exceptions. Languages like Mandarin have a relatively complex C^G system. Despite Duanmu (2000; 2007)'s *Articulator Dissimilation* claim, further investigation reveals a much more intricate system.

1.2 C^G Sequences: puzzles from Articulator Dissimilation

According to Duanmu (2000; 2007)'s analysis of Mandarin C^G clusters, "Identical articulators cannot occur in succession." For example, since [k] and [^{j}] are both dorsal,[2] the cluster [k^j] is missing in Mandarin as it violates *Articulator Dissimilation* (Duanmu, 2007: 28–30). The dorsal obstruents [k] and [x] cannot be followed by the dorsal glide [^{j}] since they share the same articulation place, as shown in (1a-b).

(1) a. *[k^{j}VX]

[k]		[^{j}]
DOR	✗	DOR

b. *[x^{j}VX]

[x]		[^{j}]
DOR	✗	DOR

On the other hand, Duanmu (2000; 2007) argues that if the consonant and the following glide have different articulators, they are permitted since they do not violate *Articulator Dissimilation* (Duanmu, 2007: 28–30). As exemplified in (2a), the consonant [t^h] is a coronal stop, and it combines with the dorsal glide [^{j}]. Similarly in (2b), the labial [m] plus palatal [^{j}] are permitted.

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[1] Kochetov (2016: 3–4) argues that consonant plus palatal glide [j] onsets are marked cross-linguistically, because the palatal articulation of the glide conflicts with other tongue movements, and the palatal glide obscures acoustic perception. Kirundi C + [w] sequences are also avoided.

[2] In this paper, I follow Duanmu (2000; 2007) and many others in analyzing the glides [j ɥ w] as Dorsal, with the latter two also having a Labial place feature specification. See section 2.3 for more discussion.

(2) a. [tʰʲau]

[tʰ]	+	[ʲ]
COR		DOR

b. [mʲan]

[m]	+	[ʲ]
LAB		DOR

However, there are problems with *Articulator Dissimilation* (Duanmu, 2007). In (3a), the coronal affricate [ts] cannot combine with dorsal [ʲ] although they have different place features and do not violate *Articulator Dissimilation*. The same is true for the cases in (3b): the labial-dorsal sequence [fʲ] is ruled out although they do not violate *Articulator Dissimilation*.

(3) *[tsʲVX]

[ts]		[ʲ]
COR	?	DOR

*[fʲVX]

[f]		[ʲ]
LAB	?	DOR

On the other hand, as shown in (4), the palatal obstruent [tɕ] can precede the palatal glide [ʲ], even though they both have the dorsal place feature, violating *Articulator Dissimilation* (Duanmu, 2007).

(4) [tɕʲVX]

[tɕ]		[ʲ]
COR, DOR	?	DOR

Articulator dissimilation itself is not enough to explain all the Mandarin data. A few questions are left unanswered. First, the place features of some consonants like [f] and [ts, tsʰ, s] (i.e., Labial and Coronal, respectively) are not the same as the dorsal glide [ʲ], but the relevant C+ʲ combinations are still missing in Standard Chinese. Second, the palatal consonants [tɕ, tɕʰ, ɕ], which bear the place features [dorsal, coronal], create challenges for *Articulator Dissimilation* (Duanmu, 2007). For example, palatal consonants can occur before the palatal glide [ʲ] despite the fact that they share the dorsal articulator.

In (5), the various possible CG combinations in Mandarin are noted, along with the predictions of Duanmu's *Articulator Dissimilation* (2007). As displayed in the third column of Mandarin data, in some cases, the Mandarin data conforms to the *Articulator Dissimilation* predictions (e.g. Lab + Lab [ʷ, ᑫ]), but in most cases, it does not. For instance, Labial + Dorsal [ʲ] combinations are predicted to be allowed, yet the onset [fʲ] is missing in Mandarin.

In this paper, we will investigate the factors that influence the forms illustrated in (5). In sections 2 to 5, I study the Mandarin consonants plus three glides [j, ɥ, w]. I propose four phonological constraints to explain Mandarin onset data: *C^{G}-Lab^{Lab}, Agree[back]:Dor^{G}, Agree[back]:$C_{[-son]}{}^{ɥ}$ and Agree[back]:$C_{[-son,\ +cont]}{}^{j}$. In section 6, I analyze the alternative approach where the palatal glides [j] and [ɥ] are analyzed as coronals instead of dorsals. The alternative analyses are not improvements, and in fact result in a more complicated analysis than the proposal advocated here. Lastly, in section 7 I summarize the analysis on C^{G} onsets in Mandarin Chinese language, and I conclude the paper.

(5) Predictions of *Articulator Dissimilation* (2007) and Mandarin Data
(* = ungrammatical or unattested; √ = grammatical and attested)

C^{G}	Predictions of *Articulator Dissimilation*	Mandarin Data
Lab + Dor [^{j}]	√[p^{j}, p^{hj}, m^{j}, f^{j}]	√[p^{j}, p^{hj}, m^{j}] *[f^{j}]
Lab + Lab, Dor [^{w}, ^{ɥ}]	*[p^{w}, p^{hw}, m^{w}, f^{w}] *[$p^{ɥ}$, $p^{hɥ}$, $m^{ɥ}$, $f^{ɥ}$]	*[p^{w}, p^{hw}, m^{w}, f^{w}] *[$p^{ɥ}$, $p^{hɥ}$, $m^{ɥ}$, $f^{ɥ}$]
Cor + Dor [^{j}]	√[t^{j}, t^{hj}, n^{j}, l^{j}, $\widehat{ts}^{hj}$, $\widehat{ts}^{j}$, s^{j}, $\widehat{ʈʂ}^{hj}$, $\widehat{ʈʂ}^{j}$, $ʂ^{j}$, $ʐ^{j}$]	*[$\widehat{ts}^{hj}$, $\widehat{ts}^{j}$, s^{j}, $\widehat{ʈʂ}^{hj}$, $\widehat{ʈʂ}^{j}$, $ʂ^{j}$, $ʐ^{j}$] √[t^{j}, t^{hj}, n^{j}, l^{j}]
Cor + Lab, Dor [^{w}, ^{ɥ}]	√[t^{w}, t^{hw}, n^{w}, l^{w}, $\widehat{ts}^{hw}$, $\widehat{ts}^{w}$, s^{w}, $\widehat{ʈʂ}^{hw}$, $\widehat{ʈʂ}^{w}$, $ʂ^{w}$, $ʐ^{w}$] √[$t^{ɥ}$, $t^{hɥ}$, $n^{ɥ}$, $l^{ɥ}$, $\widehat{ts}^{hɥ}$, $\widehat{ts}^{ɥ}$, $s^{ɥ}$, $\widehat{ʈʂ}^{hɥ}$, $\widehat{ʈʂ}^{ɥ}$, $ʂ^{ɥ}$, $ʐ^{ɥ}$]	√[t^{w}, t^{hw}, n^{w}, l^{w}, $\widehat{ts}^{hw}$, $\widehat{ts}^{w}$, s^{w}, $\widehat{ʈʂ}^{hw}$, $\widehat{ʈʂ}^{w}$, $ʂ^{w}$, $ʐ^{w}$, $n^{ɥ}$, $l^{ɥ}$] *[$t^{ɥ}$, $t^{hɥ}$, $\widehat{ts}^{hɥ}$, $\widehat{ts}^{ɥ}$, $s^{ɥ}$, $\widehat{ʈʂ}^{hɥ}$, $\widehat{ʈʂ}^{ɥ}$, $ʂ^{ɥ}$, $ʐ^{ɥ}$]
Cor, Dor + Dor [^{j}]	*[$tɕ^{hj}$, $tɕ^{j}$, $ɕ^{j}$]	√[$tɕ^{hj}$, $tɕ^{j}$, $ɕ^{j}$]
Cor, Dor + Lab, Dor [^{w}, ^{ɥ}]	*[$tɕ^{hw}$, $tɕ^{w}$, $ɕ^{w}$] *[$tɕ^{hɥ}$, $tɕ^{ɥ}$, $ɕ^{ɥ}$]	*[$tɕ^{hw}$, $tɕ^{w}$, $ɕ^{w}$] √[$tɕ^{hɥ}$, $tɕ^{ɥ}$, $ɕ^{ɥ}$]
Dor + Dor [^{j}]	*[k^{hj}, k^{j}, x^{j}]	*[k^{hj}, k^{j}, x^{j}]
Dor + Dor, Lab [^{w}, ^{ɥ}]	*[k^{hw}, k^{w}, x^{w}] *[$k^{hɥ}$, $k^{ɥ}$, $x^{ɥ}$]	*[$k^{hɥ}$, $k^{ɥ}$, $x^{ɥ}$] √[k^{hw}, k^{w}, x^{w}]

1.3 CG vs. C^{G}

Shaw, Oh, Durvasula & Kochetov (2021: 467) demonstrate that segment sequences (e.g. /pj/, /kw/) and complex segments (e.g. /p^{j}/, /k^{w}/) differ in the synchronicity and relative timing between the labial and the palatal gesture. For instance, the constituent gestures of Russian

[pʲ] are coordinated based on their gesture onsets; while English [pj] are coordinated based on the offset of the first gesture and the onset of the second. Veloso (2019: 513–514) argues that although complex segments are phonetically realized as singletons, at the phonological level, they correspond to two independent, successive and discrete segmental units. Kochetov (2016: 2–18) maintains that the glides [j, w] can trigger the target consonant to acquire secondary palatal/labial articulation or shift its primary articulation. For instance, in Kirundi, /ku-kubit-w-a/ > [gukubitkʷa], a velar is produced with secondary labial articulation. Kochetov (2016: 3, 27) outlines the possible strategies to avoid hetero-morphemic or tautomorphemic C + [j, w] combinations, including: (a) the primary articulation spreads its features (e.g. nasality) to the secondary articulation as in /am-wa/ > [am-ŋa]; (b) one of two articulations is deleted as in /pja/ > [pa]; (c) two articulations merge together as in /mja/ > [ɲa]; (d) two articulations switch positions as in /apja/ > [ajpa].

Regardless of whether an onset is phonetically one or two segments, the phonological restrictions on the co-occurrence of the sub-units merit further investigation. In Mandarin, Wang (1999: 128–129) and Duanmu (2000) argue that CG sequences, as in the syllable [nwo] ‘move’, consist of two phonological segments: a consonant and a glide. Yip (2003: 779) finds that Mandarin pre-nuclear glides belong to both the onset and the rhyme. Some studies (Chao 1934: 42) contend that CG sequences function as single sounds, due to the near-simultaneous articulation of the consonant and glide—unlike English [sw], where [s] precedes the lip rounding of [w]. Duanmu (2007: 25, 79–80) likewise treats Mandarin CG sequences as unitary segments occupying a single timing slot, where the consonant represents the primary articulation and the glide represents the secondary articulation. Liu (2022: 151), based on phonetic measurements such as glide duration, F2 slope changes, and vowel-to-glide coarticulation, finds that the Mandarin palatal glide /j/ shares more phonetic similarity with the Russian palatalized [ʲ] than with the Russian segmental [j], suggesting it is more accurately analyzed as a secondary articulation. Based on phonetic evidence, the present study adopts the representation of complex onsets: $\text{Consonant}^{\text{Glide}}$ (C^{G}). Even if such onsets are phonetically realized as singletons, they nevertheless comprise two successive and discrete (although overlapping) phonological units, each bearing distinct articulator, place, and manner features. This study thus focuses on the interactions and constraints between these two sub-units within Mandarin complex onsets.

1.4 Palatals + Glides

Duanmu (2007: 31–34) argues that the palatal consonants [tɕ, tɕʰ, ɕ] are synchronically in complementary distribution with the velars, dentals, and retroflexes—namely [k, kʰ, x], [ts, tsʰ, s], and [tʂ, tʂʰ, ʂ]—when combined with the glide [j]. However, this assumption

does not account for the possibility of palatal + glide ([j, ɥ]) sequences, particularly in cases involving G-spreading (Duanmu 2007: 60), where high nuclear vowels spread to palatal consonants. For instance, [tɕi]→[tɕʲi], [tɕu]→[tɕʷu], [tɕy]→[tɕᶣy] suggest that such sequences are phonetically plausible. Duanmu (2007: 31–33) also notes variation in Mandarin pronunciation among speakers. For example, the syllable 劝 ('persuade') may be pronounced as [tsʰᶣan] or [tɕʰʷan]; 橘 ('tangerine') as [tsᶣy] or [tɕʷy]; and 尖 ('sharp') as [tsʲan] or [tɕan]. Yet, alternative forms such as [tɕʰᶣan], [tɕᶣy], and [tɕʲan] are not definitively ruled out.

This study argues that Mandarin phonology does permit sequences where palatal consonants [tɕ, tɕʰ, ɕ] precede palatal glides [j, ɥ], forming complex CG onsets such as [tɕʲ, tɕʰʲ, ɕʲ, tɕᶣ, tɕʰᶣ, ɕᶣ], based on the following considerations: (i) there is insufficient phonetic evidence to categorically exclude the existence of onsets such as [tɕʲ, tɕʰʲ, ɕʲ, tɕᶣ, tɕʰᶣ, ɕᶣ]; (ii) other fricatives/affricates exhibit backness agreement with following glides (e.g., [tsʷ, xʷ] are attested, whereas *[tsʲ, tsᶣ, xʲ, xᶣ] are unattested). It would be phonologically inconsistent for the palatal fricatives/affricates to violate the backness agreement while others do not; (iii) the two sets of sequences—[tɕʷ, tɕʰʷ, ɕʷ] and [tɕᶣ, tɕʰᶣ, ɕᶣ]—are perceptually distinct, primarily due to the frontness of their vocoids. This perceptual contrast implies they are not interchangeable and thus phonologically distinct; (iv) Under the G-spreading hypothesis, high vowels may spread to consonant positions, i.e. [Ci]→[Cʲi], [Cu]→[Cʷu], [Cy]→ [Cᶣy]. If such spreading applies to other consonants, there is no principled reason to exclude palatals from undergoing the same process. Given these factors, there is no clear evidence to disallow C^G sequences involving palatal consonants followed by palatal glides in Mandarin. This study, therefore, treats these sequences as phonologically licit and worthy of further investigation.

2 Inventories of Mandarin Consonants and Vowels

Among the four elements of a Mandarin syllable, i.e. (C) (G) V (X), all except the nuclear vowel are optional in a syllable structure. The following sections illustrate the consonants, vowels, and glides in Mandarin Chinese (MC). (See Appendix 1 for a chart of the feature specifications adopted in this paper.)

2.1 Consonants

The consonant inventory in Mandarin Chinese is displayed in (6), which is adapted from Luo & Wang (1981), Chao (1968) and Duanmu (2000: 26, 37, 49–50; 2007). I only include the features that are relevant for the discussion in this paper.

(6) MC consonant inventory

		LAB	COR				DOR
		Labial	Alveolar	Dental	Retroflex	Palatal	Velar
	Manner	*Dor [0back]	*Dor [0back]	*Dor [0back]	*Dor [0back]	Cor, Dor [-back]	Dor [+back]
Obstruent	Stops [-cont]	p^h, p	t^h, t				k^h, k
	Fricatives [+cont]	f		s	ʂ, ʐ	ɕ	x
	Affricates [±cont]			$\widehat{ts}^h$, $\widehat{ts}$	$\widehat{tʂ}^h$, $\widehat{tʂ}$	$tɕ^h$, tɕ	
Sonorant	Nasals [-cont]	m	n				ŋ
	Liquids [+cont]		l				

Among the 22 consonants in Mandarin, the velar nasal [ŋ] is the only one that cannot occur at the onset position, which is similar to English. The nasals in Mandarin Chinese include labial [m], alveolar [n] and velar [ŋ]. There are six fricatives: labio-dental [f], dental [s], palatal [ɕ], velar [x] and the retroflex [ʂ, ʐ]. The stops are either aspirated: [p^h, t^h, k^h], or unaspirated [p, t, k]. In Mandarin, affricates include dentals [$\widehat{ts}$, $\widehat{ts}^h$], palatals [$tɕ^h$, tɕ] and the retroflexes [$\widehat{tʂ}^h$, $\widehat{tʂ}$]. This study follows Riggle (2011) and label affricates as [±cont]. Besides nasals and vowels, the sonorants in Mandarin Chinese include one liquid: the alveolar lateral [l], although the lateral [l] can be missing in many varieties, like Chengdu Chinese.

In the consonant inventory (6), the voiced retroflex sound is transcribed as the fricative [ʐ], which follows Karlgren's (1915–26; 2003) and Dong's (1958: 39) analyses. Yet, in Duanmu's (2000: 26; 2007) study, this sound is transcribed as a retroflex liquid [r] instead of fricative [ʐ] (see also Fu 1956: 3; L. Wang, 1980). Duanmu (2000: 26)'s argument for adopting [r] rather than [ʐ] is that fricatives in Standard Chinese [f, s, ʂ, ɕ, x] are all [-voice], so it is "phonologically odd" to include [ʐ] as the only [+voice] one. However, the present paper maintains that the voiced fricative [ʐ] patterns with its voiceless counterpart [ʂ] in the Mandarin consonant inventory, following Duanmu (2007: 24). The voicing alternations [s, z, ʂ, ʐ] and the anterior pairs [s, ʂ, z, ʐ] exist in many Chinese varieties, like Fuyang dialect (阜阳话). Besides, phonologically, the

voiced retroflex behaves more like an obstruent than a sonorant; for instance, all initial sonorants in Mandarin can be followed by [j], yet the voiced retroflex + [j] is missing just like other fricatives + [j] sequences.

According to Odden (1991: 261, 262), the dorsal place node covers [high], [low] and [back] values (see also Clements 1985; Sagey 1986; McCarthy1988; Kenstowicz 1994). Mandarin palatals [tɕʰ, tɕ, ɕ] are both dorsal and coronal with [-back] features (Hayes 2011: 95–97; Riggle 2011). In (6), labials and non-palatal coronals do not carry an [back] value, thus they are [0back].

2.2 Vowels

In Mandarin Chinese, there are 5 vowels (adapted from Duanmu 2000: 37, 50; 2007: 35–39), more specifically, five monophthongs: [i, y, u, ə, a] in (7). Among these monophthongs, the three high vowels [i, y, u] can be realized as glides or monophthongs in Standard Chinese. The mid and low vowels [ə, a] are allowed to follow every initial consonant. The present paper focuses on the interactions inside Mandarin C^G onsets.

(7) Five vowels in Mandarin

Vowel	Height	Backness
i	high	front
y	high	front
u	high	back
ə	mid	central
a	low	central

Based on previous analyses (Chao 1968; Cheng 1973; Xu 1980: 33; Duanmu 2007: 37), the mid central vowel can take on forms like [o, E, ɤ, e, ə]. Fu (1956: 6) argued that [ɤ] appears after a labial sound. Duanmu (2000; 2007: 38) maintains that after labials, both back vowel [o] and mid vowel [ɤ] can occur. In a nutshell, forms like [mʷo](末 'end') and [mɤ](末 'end') are non-contrastive.

2.3 Glides

Padgett (2008: 2) argues that glides and vowels differ in both articulatory dynamics and stricture: vowels tend to be more intense, acoustically steady, and produced without friction, whereas glides are typically less intense, may involve friction, and are characterized by rapid formant

transitions. Yip (2003: 779) observes both inter-speaker and intra-speaker variation in the analysis of Mandarin pre-nuclear glides, with speakers treating them variably as part of the onset or part of the rhyme. Some phonologists (Wang 1993; Pulleyblank 1983) propose that there are no high vowels in Mandarin Chinese, because their underlying representation are all glides; Pulleyblank (1983) even argues that the low vowel [a] is a pharyngeal glide as well. The present paper follows Duanmu (2000; 2007)'s argument that there are three glides in Mandarin: [j, w, ɥ], which are exemplified in (8). The relevant features of glides and vowels are illustrated in (9).

(8) Non-contrastive transcriptions

编 [pʲan] 'weave'
准 [tʂʷən] 'accurate'
学 [ɕᶣe] 'study'

(9) Glide-vowel correspondence table in Mandarin (adapted from Duanmu 2000; 2007)

Glide	High vowels	Features
[j]	[i]	[-back, +high, -ro]
[ɥ]	[y]	[-back, +high, +ro]
[w]	[u]	[+back, +high, +ro]

The place feature specification of glides is debated. Riggle (2011) labels the glides [j, ɥ, w] as dorsal and non-coronal (see also Kenstowicz 1994; Duanmu 2007; Hayes 2011), while others specify the front glide [j] as coronal (Kochetov 2016; Meeussen 1959; Broselow & Niyondagara 1990; Hume 1990; 1994; 1996; Ntihirageza 1993). In this paper, I adopt the analysis of the glides as dorsal and non-coronal; however, I investigate an alternative analysis in section 6 with the glides [j, ɥ] having a coronal place specification.

The articulator features of the three glides in Mandarin Chinese adopted in this paper are illustrated in (10). Since the high glides are all dorsal, the backness feature, which is relevant for the C^G analysis, is indicated. The rounded glides [ɥ, w] also have a labial feature.

(10) Mandarin Glide Inventory

Manner	LAB	COR	DOR	
			[-back]	[+back]
Glides [+cont]	ɥ, w		j, ɥ	w

2.4 VG and GV

Although [i, y, u] are all high vowels and can occupy the first slot in a diphthong (glide position), only [i] and [u] can occupy the second position in a diphthong (Duanmu 2000: 38; 2007), functioning as offglides at the end of a syllable. This distributional restriction provides evidence that [y] is more marked than [i] and [u]. Based on Duanmu (2000: 42)'s analysis, there are four falling diphthongs (VG) in Mandarin Chinese, namely, the mid ones [əi, əu] and the low ones [ai, au]. For instance, [tʰai]/[tʰaj] and [mai]/[maj] consist of an onset consonant and a following diphthong with the high vowel [i] as the offglide.

(11) Consonant + Glide[j/ɥ/w] + Vowels:

	Pinyin	IPA	Chinese character	English counterpart
(a)	tie	t + ʲ + e	贴	'glue'
(b)	lie	l + ʲ + e	列	'column'
(c)	jüe	tɕ + ᶣ + e	觉	'think'
(d)	qüe	tɕʰ + ᶣ + e	却	'but'
(e)	tuo	t + ʷ + o	拖	'drag'
(f)	nuo	n + ʷ + o	挪	'move'

In Mandarin Chinese, the glides [j], [ɥ] and [w] can occur before nuclear vowels (11). For example, the palatal approximant [j] stands after the onset consonant [t]/[l] and before the nucleus [e]; The labial dental approximant [ɥ] appears between the palatal affricate [tɕ]/ [tɕʰ] and the vowel [e]. In the following sections (3–5), Mandarin consonants plus the glides /j, ɥ, w/ are analyzed respectively.

3 Consonant + /j/

This section discusses combinations of word-initial consonants plus the palatal glide [j] (see also Appendix 2). The word-initial consonants have different place features: labials, alveolars, dentals, retroflexes, palatals and velars are illustrated respectively.

3.1 Labial + Palatal [j]

Some labial consonant + palatal [j] groups are allowed in Mandarin Chinese (12). The labial [-cont] consonants [p, pʰ, m] allow the following palatal glide [j] (pʲ, pʰʲ, mʲ) as onsets. In contrast, the labial fricative [f] plus [j] sequence is not allowed in Mandarin. In (12), the "√" symbol indicates the occurrence of a Consonant + Glide group in the relevant language; the "*" symbol marks when a Consonant + Glide form is missing in the relevant language.

(12)

	C	C^j
Labial	p	√
	p^h	√
	m	√
	f	*

The voiceless labio-dental fricative [f] is the only [+continuant] consonant among the labials. In Mandarin Chinese, if the first labial consonant is not [+cont], it can be followed by the palatal glide [j], as displayed in (13). For instance, the first labial consonant is [m] carrying a [-cont] feature, it can precede [j] and form a complex onset [m^j] in words like [m^jan] (面 'noodle') or [m^ji] (蜜 'honey'). The same is true for the sequences [p^j] and [p^{hj}] where the initial consonants [p, p^h] are [-cont].

(13) [p, p^h, m] [^{j}]
[Lab] [Dor]
[0 cont]

(14) * [f] [^{j}]
[Lab] [Dor]
[+cont]

In contrast, if the first labial consonant in onset position is [+continuant], it cannot combine with the glide [j] as onset. As shown in (14), the initial labial fricative [f] cannot stand together with [j]. Duanmu (2000: 51; 2007: 49) argues that although the sequence [f^j] appears in some Chinese dialects and in English, its absence in Mandarin constitutes an accidental gap. However, this study contends that the non-occurrence of [f^j] in Mandarin is not accidental but rather predictable under the Sonority Scale Principle.

According to the Sonority Hierarchy (Broselow & Finer 1991: 37–38), with stops being the least sonorous, the sonority values assigned to stops, affricates, fricatives, and glides are 1, 1.5, 2, and 5, respectively. Consequently, the sonority distances (SD) for stop-glide, affricate-glide, and fricative-glide onsets are 4, 3.5, and 3, respectively (see also Lin 2001: 3–4). Zhao and Berent (2016: 796, 809) found that Mandarin speakers disprefer onsets with small sonority distance, even though Mandarin permits only C + G clusters and is otherwise cluster-poor. Within the class of obstruents, the smaller the sonority distance between the obstruent and the glide, the more marked and less likely the cluster is to occur. Thus, stop + [j] sequences are less marked than fricative or affricate + [j] sequences. From this perspective, the absence of [f^j] in Mandarin reflects not an accidental gap, but rather alignment with a universal sonority-based

preference. Cross-dialectal evidence supports this asymmetry. In Lanzhou Chinese, stops may precede both glides [j] and [w], whereas fricatives and affricates can only precede [w]. Similarly, in Fuyang Chinese, all stop + glide sequences are attested (Liu & Repetti 2020), while fricatives and affricates must agree in backness with the following glide ([j, ɥ, w]), further supporting the notion that stop + glide onsets are less marked. Therefore, the absence of [fʲ] in Mandarin is likely due to the fricative manner of [f], which yields a smaller sonority distance (SD = 3) in comparison to stop + [j] sequences (SD = 4). This makes [fʲ] more marked and subject to phonotactic restrictions. Mandarin's avoidance of such clusters thus conforms to universal principles of sonority sequencing.

3.2 Non-palatal coronals + [j]

Some phonologists (Chao 1968; Duanmu 2007; Zhou & Wu 1963) refer to the coronal consonants [t, tʰ, n, l, ts, tsʰ, s] as dentals, other studies like Kratochvil (1968) and Luo & Wang (1981) classify the coronal sounds in Mandarin into four categories: the alveolar sounds [t, tʰ, n, l], the dental sounds [t͡s, t͡sʰ, s], the retroflexes [t͡ʂ, t͡ʂʰ, ʂ, ʐ] and the palatals [tɕ, tɕʰ, ɕ]. Table (15) lists all the non-palatal coronals plus [j] onsets. The coronal stops [t, tʰ] and sonorants [n, l][3] can be followed by the palatal glide [j] in onset position. In (16), the initial stops in onset position that are not [+ cont], can be followed by the glide [j].

(15)

	C	Cʲ
non-palatal coronal	t	√
	tʰ	√
	n	√
	l	√
	ts	*
	tsʰ	*
	s	*
	tʂ	*
	tʂʰ	*
	ʂ	*
	ʐ	*

[3] Mielke (2005) argues that [n, l] are [+ continuant]. The constraint (18) Agree[back]: $C_{[\text{-son, } +\text{cont}]}{}^{j}$ applies exclusively to [-son] initials—that is, obstruents—so the continuancy features of [n, l] are irrelevant in this context.

(16) [t, t^h] [^{j}]
[Cor] [Dor]
[-son][-cont]

The onset combinations of the fricatives and affricates [t͡s, t͡s^h, s, t͡ʂ, t͡ʂ^h, ʂ, ʐ] plus [j]: [t͡s^j, t͡s^{hj}, s^j, ʂ^j, ʐ^j, t͡ʂ^j, t͡ʂ^{hj}] are missing in Mandarin Chinese. The fricatives [s, ʂ, ʐ] are [+cont], whereas the affricates [t͡s, t͡s^h, t͡ʂ, t͡ʂ^h] are specified as [±cont]. With the feature [+cont] or [±cont], they cannot be followed by the glide [j]. For example, words like晒 [ʂai] ('bask') are allowed, but *[ʂ^{j}ei] are missing.

3.3 Palatals + [j]

The palatal consonants [tɕ, tɕ^h, ɕ] in Mandarin are all [+cont], so we might expect sequences of palatals + [j] to be banned, like other fricatives and affricates in Mandarin. However, as shown in (17), all Pal + [j] sequences can stand in the onset position.

(17)

	C	C^j
palatal	tɕ	√
	tɕ^h	√
	ɕ	√

The generalization appears to be that [-back] consonants (palatals) and the [-back] glide ([j]) can form a cluster, overriding the ban on affricates and fricatives plus [j]. I formulate this as an Agree (anti-OCP) constraint: a [+cont] consonant (affricate or fricative) must agree in backness with the following palatal glide ([j]), i. e., it must be [-back]. Backness agreement means that both the consonant and the glide must agree in backness. If the consonant is [0back] because it does not have a dorsal feature, then it cannot satisfy the constraint. The constraint (18) only refers to [+cont] obstruents, which means that [-cont] obstruents and all sonorants are exempted, regardless of their feature specification.

(18) Agree Constraint (Anti-OCP)
Agree [back] : $C_{[-son,\ +cont]}{}^{j}$
A [-son, +cont] consonant (affricate or fricative) must agree in backness with the following [-back] glide ([j]).

The constraint (18) Agree[back]: $C_{[-son,\ +cont]}{}^{j}$ aligns well with the universal sonority scale, and Mandarin onsets conform to this sonority-based pattern. Because fricative and affricate + glide sequences have lower sonority distances, they are more marked and consequently more likely to be absent in Mandarin. In contrast, stop + [j] sequences exhibit higher sonority distances, making them less marked and thus not restricted by constraint (18).

3.4 Velars + [j]

The velar consonants [k, k^h, x] plus the palatal glide [j] are missing in Mandarin (19).

(19)

	C	C^j
velar	k	*
	k^h	*
	x	*

According to Duanmu (2000; 2007)'s *Articulator Dissimilation*, the dorsal consonants [k, k^h, x] do not combine with the dorsal unrounded glide [j] because the two adjacent sounds share the same place feature. However, this is not enough to explain all the data. First, the palatals [tɕ, $tɕ^h$, ɕ] are both coronal and dorsal in terms of place features, and they can occur with the dorsal glide [j]. Second, the velar glide [w] also has a dorsal place feature, yet velar consonant plus [w] groups are allowed in Mandarin.

In order to solve these problems, I propose another Agree (anti-OCP) phonotactic constraint in terms of the backness: the dorsal consonants and the following glide must agree in backness. Since the velar consonants [k, k^h, x] are [+back] (Riggle 2011), they cannot be followed by the [-back] glide [j].

(20) Agree Constraint (Anti-OCP)
Agree [back] : Dor^j
A Dor^j sequence must agree in backness.

3.5 Summary

Taking all the C^j onsets into account, it seems that stop/liquid/nasal +j groups are always grammatical, except the velar stops. Meanwhile, a fricative/affricate +j sequence is not allowed, except palatals +j. Both exceptions can be accounted for with a single backness agreement constraint. When Mandarin consonants precede the glide /j/ in onset position, the affricates and fricatives are required to agree with the glide /j/ in backness value: [-back]. The anti-OCP constraint Agree[back]:$C_{[-son,\ +cont]}{}^j$ is defined in (18). Among all fricatives and affricates, only the palatals carry the same [-back] value as the glide /j/. Therefore, the labial ([f]) and the non-palatal coronals ([ts^j, ts^{hj}, s^j, $tʂ^j$, $tʂ^{hj}$, $ʂ^j$, $z_ɻ^j$]) which have no [back] feature, and the dorsals ([k, k^h, x]) which have a [+back] value, cannot form an onset cluster with [j] which has a [-back] value.

The palatals, velars, and glide [j] all have a dorsal place. Since the features [+back] and [-back] are part of dorsal, the dorsal segments must agree on all of the features dependent on the dorsal node. In other words, adjacent consonants plus [j] must share their [back] value. Thus, another constraint on Mandarin C^j sequences requires a dorsal consonant to agree with the glide

/j/ in backness value: [-back]. The anti-OCP constraint Agree[back]: Dor^{j} is shown in (20). The dorsal consonants [k, k^{h}, x] are [+back], and have the opposite value of the [-back] glide /j/. Therefore, the sequences [kj, k^{hj}, x^{j}] are missing. Taking non-dorsal segments into consideration, even if there is no dorsal node, the agreement constraint still holds. In other words, CG must both have the same backness value: both are [+back] or both are [-back]. CG combinations like [+back, -back], [-back, +back], [0back, +back] or [0back, -back] would not satisfy backness agreement. Note that the articulator feature nodes themselves are not explanatory enough. The agreement on backness between consonants and the glide /j/ plays a significant role in the grammaticality of the relevant CG onsets.

4 Consonant + [ɥ]

Hockett (1947) argued that the diphthong [iu] can be written as the high vowel [y] (the glide [ɥ]). However, to analyze the glide [ɥ] as syllable onset, the following analysis will not resort to Hockett's approach. This section describes the phonotactic behaviors and constraints of consonant plus labial palatal glide [ɥ] sequence as onset in Mandarin Chinese (see also Appendix 3).

4.1 Labial + [ɥ]

As shown in (21), when the first labial consonants are followed by a labial glide [ɥ], the CG pairs are disallowed to avoid the redundancy of roundness or LAB place feature.

(21)

	C	C^{ɥ}
labial	p	*
	p^{h}	*
	m	*
	f	*

The markedness constraint *C^{ɥ}-LabLab originates from Duanmu (2000; 2007)'s articulator differentiation rule, which rules out all labials plus [ɥ] groups. For instance, the words 米[mi] ("rice") and 旅[lɥ] ("travel") are allowed, whereas words like *[m^{ɥ}i] and *[m^{ɥ}e] are missing in MC. (Forms like *[my], *[myn] are also missing, although an analysis of them is beyond the scope of this paper.)

(22) Constraint (OCP)
***C^{ɥ}-Lab^{Lab}**
If the initial consonant is labial, it cannot occur with a labial glide [ɥ].

4.2 Non-palatal coronals + [ɥ]

The non-palatal coronals plus the labial front glide [ɥ] groups are listed in (23). If the initial non-palatal coronal is not a sonorant, it cannot occur with the glide [ɥ].

(23)

	C	$C^{ɥ}$
non-palatal coronal	t	*
	t^{h}	*
	n	√
	l	√
	ts	*
	ts^{h}	*
	s	*
	tʂ	*
	$tʂ^{h}$	*
	ʂ	*
	z̩	*

The coronal stops + [ɥ], namely, [$t^{ɥ}$, $t^{hɥ}$], are missing; yet the sonorants + [ɥ] ones ([$n^{ɥ}$, $l^{ɥ}$]) are allowed. Apart from that, Mandarin disallows non-palatal fricatives and affricates + [ɥ] combinations: *[$ts^{ɥ}$, $ts^{hɥ}$, $s^{ɥ}$, $tʂ^{ɥ}$, $tʂ^{hɥ}$, $ʂ^{ɥ}$, $z̩^{ɥ}$]. If the initial consonant is [+cont], but not a palatal, it cannot occur with the front glide [ɥ].

4.3 Palatals + [ɥ]

As displayed in (24), Pal + [ɥ] combinations are allowed. For instance, words like卷[tɕ^{ɥ}an] (‘roll’), 却[tɕ^{hɥ}e] (‘but’), 寻[ɕ^{ɥ}ən] (‘search’) can occur in Mandarin.

(24)

	C	$C^{ɥ}$
palatal	tɕ	√
	$tɕ^{h}$	√
	ɕ	√

(25) Constraint (Anti-OCP)
Agree [back] : $C_{[-son]}{}^{ɥ}$
The initial obstruents and the following glide [ɥ] must have the same backness value.

The initial obstruent consonant and the glide in onset position need to have the same backness value. Given that Mandarin has only three sonorant initials—[m, n, j]—constraint (25) demonstrates that the glide [ɥ] is highly restricted in its distribution. The phonotactic markedness constraint *Agree[back]:$C_{[-son]}{}^{ɥ}$ describes the backness agreement between the initial consonant and the following glide [ɥ]. Since the palatal consonants [tɕ, tɕʰ, ɕ] are [-back], they can be followed by the [-back] palatal glide [ɥ].

4.4 Velars + [ɥ]

As shown in (26), velars plus labial palatal glide [ɥ] sequences are not allowed in Mandarin: *[$k^{ɥ}$, $k^{hɥ}$, $x^{ɥ}$]. The constraint Agree[back]:Dorɥ explains the ungrammaticality of velars followed by the front glide [ɥ]. Since all Mandarin velars are [+back], which disagree with the [-back] glide [ɥ], the relevant combinations cannot hold and are therefore missing in Mandarin.

(26)

	C	$C^{ɥ}$
velar	k	*
	k^{h}	*
	x	*

(27) Agree Constraint (Anti-OCP)
Agree [back] :$Dor^{ɥ}$
A $Dor^{ɥ}$ sequence must agree in backness.

Only patatals and sonorants [n, l] can be followed by [ɥ]. The constraint Agree[back]:$C_{[-son]}{}^{ɥ}$ (25) rules out all obstruents + [ɥ] groups, yet still keeps the Pal^{Pal} groups [tɕ^{ɥ}, tɕ^{hɥ}, ɕ^{ɥ}] and SonSon groups [n^{ɥ}, l^{ɥ}]. This restriction can be predicted by the high markedness of the glide [ɥ]. According to data from PHOIBLE (Moran & McCloy, 2019), only 2% of the languages in the database feature the glide [ɥ], whereas [j] occurs in 90% of languages and [w] in 82%.

4.5 Summary

When Mandarin consonants precede the glide [ɥ] in onset position, the obstruents are required to agree with the glide /ɥ/ in backness value: [-back]. The anti-OCP constraint Agree[back]:$C_{[-son]}{}^{ɥ}$ as defined in (25) is obeyed by Mandarin onsets. Among all stops, affricates and fricatives, only the palatals carry the same [-back] value with the glide /ɥ/. Therefore, the labials obstruents +

ɥ: [pᶣ, pʰᶣ, fᶣ], the non-palatal coronals + ɥ: [tᶣ, tʰᶣ, tsᶣ, tsʰᶣ, sᶣ, tʂᶣ, tʂʰᶣ, ʂᶣ, zᶣ, tʂᶣ, tʂʰᶣ, ʂᶣ, zᶣ] and the dorsals + ɥ: [kᶣ, kʰᶣ, xᶣ] are penalized. Alternatively, the constraint Agree[back]:Dorᶣ in (27) also disallows [kᶣ, kʰᶣ, xᶣ]. Another constraint in Mandarin Cᶣ sequences is *Cᶣ-Labᴸᵃᵇ (OCP), as illustrated in (22). The labial consonants [p, pʰ, m, f] have the same labial place feature as the glide /ɥ/, which violates OCP. Therefore, the absence of the sequences [pᶣ, pʰᶣ, mᶣ, fᶣ] can be accounted for by both constraint (22) *Cᶣ-Labᴸᵃᵇ (OCP) and (25) Agree[back]:$C_{[-son]}{}^{ᶣ}$ (Anti-OCP).

To summarize, backness agreement between initial obstruents and the glide /ɥ/ plays a significant role in the grammaticality of Cᶣ onsets. Apart from that, the consonants and the glide cannot both have the labial feature. Furthermore, glide asymmetry is evident in Mandarin onsets: all obstruents—including stops—combined with [ɥ] are penalized, with the notable exception of palatals. Compared to the more common glides [j] and [w], [ɥ] is typologically rare and thus subject to greater phonological restrictions.

5 Consonant + [w]

English has words with complex Cw onsets like ‘be.tween’, ‘dwarf’ and ‘sweet’. This section focuses on the C + labial velar [w] combinations in Mandarin (see also Appendix 4).

5.1 Labials + [w]

In the case of labials + velar glide [w], it is not the backness, but the roundness that plays the role of differentiation from the first onset consonant, according to Duanmu (2000; 2007)’s differentiation of articulator theory. In other words, the repetition of the labial feature in onset position is disallowed. In Mandarin, the labial consonants [p, pʰ, m, f] cannot be followed by a labial glide [w]: * [pʷ, pʰʷ, mʷ, fʷ], as shown in (28).

(28)

	C	Cʷ
labial	p	*
	pʰ	*
	m	*
	f	*

In Mandarin, when labial initials are followed by the labial glide [w], the CG pairs are penalized to avoid the redundancy of labial place feature. For instance, words like [pʷa], [pʰʷou], [mʷan], [fʷəŋ] are disallowed; but八[pa] ‘eight’, 剖[pʰou] ‘anatomy’, 慢[man] ‘slow’ and 缝[fəŋ] ‘stitch’ are grammatical.

(29) Constraint (OCP)
***C^{w}-Lab^{Lab}**
If the initial onset consonant is labial, it cannot occur with a labial glide [w].

Duanmu (1990: 68; 2000; 2007: 27, 37, 65, 69–70) observes that the sequences [p^{w}, p^{hw}, m^{w}, f^{w}] are generally absent in Mandarin, except in open syllables such as [p^{w}o, p^{hw}o, m^{w}o, f^{w}o] for some speakers. As discussed in section 2.2, following labial consonants, the mid vowel alternates between two variants: [o] and [ɤ], exemplified by [p^{w}o] and [pɤ]. Unlike other C^{w} onsets found in syllables such as [n^{w}an], [t^{w}əi], and [s^{w}ə], I analyze the underlying forms of [p^{w}o, p^{hw}o, m^{w}o, f^{w}o] are not complex onsets (C^{G}) but rather CV structures—specifically [pə, p^{h}ə, mə, fə]. This distinct underlying CV status exempts these sequences from the C^{G}-specific constraint (29) *C^{w}-Lab^{Lab}.

The markedness constraint *C^{w}-Lab^{Lab} rules out the labials plus [w] groups. Taking the previous analysis on labial consonants plus [ɥ] into the current analysis, the OCP constraint *C^{G}-Lab^{Lab} in (30) is derived.

(30) Constraint (OCP, deriving from (22), (29))
***C^{G}-Lab^{Lab}**
If the initial consonant is labial, it cannot occur with a labial glide [ɥ]/[w].

Constraint (30) also exists in several Chinese dialects. Yi and Duanmu (2015: 819, 823) report that C^{G} combinations in Lanzhou Chinese (兰州话) adhere to the *Lab^{Lab} constraint, which prohibits labial consonants from preceding labial glides [ɥ] and [w]. Notably, [ɥ] is even more marked in Lanzhou Chinese, as only palatal consonants can co-occur with this glide. In Liu and Repetti's (2020) study, the Putian dialect (莆田话) exhibits a high tolerance for C + G sequences, restricting only labial consonants before [ɥ], whereas the Fuyang dialect (阜阳话) is more restrictive, banning labial consonants before both [ɥ] and [w]. Evidence from Lanzhou, Putian, and Fuyang dialects consistently underscores the high markedness of the glide [ɥ].

5.2 Non-palatal coronals + [w]

As shown in (31), Mandarin Chinese allows coronal stops and sonorants to be followed by the labial velar glide [w]. For instance, words like 夺[t^{w}o] 'take', 吞[t^{hw}ən] 'swallow', 暖[n^{w}an] 'warm', 乱[l^{w}an] 'messy', 挪[nwo] 'move', etc. can occur in Mandarin.

Non-palatal fricatives and affricates plus [w] are allowed: [ts^{w}, ts^{hw}, s^{w}, $tʂ^{w}$, $tʂ^{hw}$, $ʂ^{w}$, $zʐ^{w}$]. The initial consonants (Cor) and the glide [w] (Dor, Lab) are articulated in different positions, which satisfies Duanmu (2000; 2007)'s Articulator Dissimilation rule. For instance, 座[ts^{w}o] 'seat', 错[ts^{hw}o] 'mistake', 算[s^{w}an] 'count', 装[$tʂ^{w}$aŋ] 'put in', 炊[$tʂ^{hw}$əi] 'kitchen', 硕[$ʂ^{w}$o] 'master' and 软[r^{w}an] 'soft'.

(31)

	C	C^w
non-palatal coronals	t	√
	t^h	√
	n	√
	l	√
	ts	√
	ts^h	√
	s	√
	tʂ	√
	$tʂ^h$	√
	ʂ	√
	zˌ	√

5.3 Palatals + [w]

The palatals plus the velar glide [w] combinations [tɕ^w, tɕ^{hw}, ɕ^w] are listed in (32). Mandarin does not allow the palatal-[w] onsets [tɕ^w, tɕ^{hw}, ɕ^w]. The missing palatals plus [w] groups are marked with "*".

(32)

	C	C^w
palatal	tɕ	*
	$tɕ^h$	*
	ɕ	*

If the [-back] feature is shared between the initial palatal consonant and the following glide, the Pal^{Pal} group is free of conflicting backness feature and is grammatical, as illustrated in (33). For instance, sounds like [tɕ^{w}ən], [tɕ^{w}ai], [tɕ^{w}an], [ɕ^{w}ən], [tɕ^{hw}ai], [ɕ^{w}an] are penalized; whereas words like 均[tɕ^{ɥ}ən] 'average', 决[tɕ^{ɥ}ei] 'decide', 捐[tɕ^{ɥ}an] 'donate', 讯[ɕ^{ɥ}ən] 'information', 缺[tɕ^{hɥ}e] 'lack' and 选[ɕ^{ɥ}an] 'choose' can occur.

(33)

*PAL + w	PAL + ɥ
Cor,Dor Dor	Cor,Dor Dor
[-back] [+back]	[-back] [-back]

(34) Constraint (Anti-OCP)
Agree [back] :Dor^{w}
A Dor^{w} sequence must agree in backness.

The backness mismatch between the initial dorsal consonant and the following glide [w] can be accounted for by the constraint Agree[back]:Dorw. Since the palatal consonants [tɕ, tɕ^{h}, ɕ] are [-back], they cannot be followed by the [+back] velar glide [w] in onset position, as defined in (34).

5.4 Velars + [w]

In (35), the velar consonants [k, k^{h}, x] plus the labial velar glide [w] combinations [k^{w}, k^{hw}, x^{w}] are allowed in Mandarin. For instance, words like瓜[k^{w}a] ‘melon’, 括[k^{hw}o] ‘include’ and洪[x^{w}uŋ] ‘flood’.

(35)

	C	C^{w}
velar	k	√
	k^{h}	√
	x	√

The CG (velar-velar) groups [k^{w}, k^{hw}, x^{w}] in Mandarin abide by the anti-OCP constraint Agree[back]:Dor^{w}, the initial velar consonant and [w] share the same backness value: [+back].

Considering all dorsal + glide combinations, we can unify the three constraints—(20) Agree[back]: Dor^{j}, (27) Agree[back]: Dor^{ɥ} and (34) Agree[back]: Dor^{w}—into a single, general constraint: (34) Agree[back]: Dor^{G}.

(36) Constraint (anti-OCP, deriving from (20), (27), (34))
Agree [back] : Dor^{G}
A Dor^{G} sequence must agree in backness.

Agreement on sub-node features such as [backness] is also attested in other language varieties. Fuyang Chinese exhibits an even stricter adherence to backness agreement than Mandarin (Liu & Repetti, 2020), requiring all fricatives and affricates to share the same backness value as the following glides [j, ɥ, w]. Similarly, Rubach (2024: 1179) argues that in Kurpian, glides inserted via glide insertion must agree in both [back] and [round] features with the subsequent vowels.

5.5 Summary

When Mandarin dorsal consonants precede the glide [w] in onset position, they are required to agree with [w] in backness value: [+back]. The anti-OCP constraint Agree[back]: Dor^{w} as defined in (34) is obeyed by Mandarin onsets. Another constraint in Mandarin C^{w} sequences is $*C^{w}$-Lab^{Lab} (OCP). Labials consonants cannot precede the labial glide [w] due to OCP. Therefore, the sequences [p^{w}, p^{hw}, m^{w}, f^{w}] are missing.

Mandarin sonorants such as [n] and [l], which involve minimal airflow obstruction and relatively open vocal tracts, can freely precede the glides [j, w, ɥ]. Following the general cross-linguistic pattern, Mandarin sonorants are less marked and subject to fewer phonotactic restrictions than obstruents. Taking all Mandarin CG onsets into consideration, there are mainly four necessary phonotactic constraints: Agree[back]:Dor^{G}, Agree[back]:$C_{[-son]}{}^{ɥ}$, Agree[back]: $C_{[-son,+cont]}{}^{j}$ and $*C^{G}$-Lab^{Lab}. Among the four constraints, $*C^{G}$-Lab^{Lab} abides by OCP whereas the other three are against OCP. The backness agreement constraints require the consonants and the following glide to have the same backness value: both are [+back] or [-back]. For instance, sequences like [s^{j}] are missing in that the initial consonant is [0back] whereas [j] is [-back]. In summary, backness agreement between the initial consonants and glides play a significant role in the grammaticality of Mandarin C^{G} onsets.

6 Front glides as coronals

According to Kochetov (2016: 7, 10), the front glide [j] is a posterior coronal glide (see also Meeussen 1959: 9–12; Broselow & Niyondagara 1990; Hume 1990; 1994; 1996: 163–165; Ntihirageza 1993: 12–13). If the front glides [j, ɥ] are taken as coronals instead of dorsals, they will not have backness values, i.e., [0back], so the backness agreement constraints are not relevant here. Instead, we will investigate an analysis using the coronal features [anterior] and [distributed]. The [ant] and [dist] feature specifications for the relevant segments are provided in (37).

(37) Mandarin coronals

Alveolars	[t, t^{h}, n, l]:	[+ant] [-dist]
Dentals	[$\widehat{ts}^{h}$, $\widehat{ts}$, s]:	[+ant] [-dist]
Retroflexes	[$\widehat{ʈʂ}^{h}$, $\widehat{ʈʂ}$, ʂ, ʐ]:	[-ant] [-dist]
Palatals	[tɕ, $tɕ^{h}$, ɕ]:	[-ant] [+dist]
Glides	[j, ɥ]:	[-ant] [+dist]

Since the ([-cont]) alveolar, dental, and retroflex obstruents pattern together, the [anterior] feature is not relevant for our analysis, as it separates the alveolars and dentals from the retroflexes. Yet, the retroflexes pattern with the alveolars and dentals, and not with the palatals. Instead, the feature [distributed] groups the alveolars, dentals, and retroflexes together: palatals and glides are [+distributed], whereas the non-palatal coronal consonants are [-distributed]. We will investigate constraints which refer to the [dist] feature.

The restrictions on C^j clusters can be accounted for with Agree[dist]:$C_{[-son, +cont]}{}^{j}$ (38) which says that fricatives and affricates must agree with the following glide [j] in distributed values. Since non-palatal fricatives and affricates [f, ts, ts^h, s, tʂ, $tʂ^h$, ʂ, zʐ, x] (as well as labial and velar fricatives) do not agree with [j] in distributed values, those combinations crash.

(38) Constraint (anti-OCP):
Agree [dist] :$C_{[-son, +cont]}{}^{j}$
The initial fricatives and affricates must agree with the following glide [j] in distributed values.

(39) Mandarin C^G with front glides specified as coronal

	C	$+^j$	Agree[dist]: $C_{[-son, +cont]}{}^{j}$	$+^{ɥ}$	Agree[dist]: $C_{[-son]}{}^{ɥ}$
labial	p	√		✗	*
	p^h	√		✗	*
	m	√		✗	*C^G-Lab^{Lab}
	f	✗	*	✗	—
coronal	t	√		✗	*
	t^h	√		✗	*
	n	√		√	
	l	√		√	
	ts	✗	*	✗	*
	ts^h	✗	*	✗	*
	s	✗	*	✗	*
	tʂ	✗	*	✗	*
	$tʂ^h$	✗	*	✗	*
	ʂ	✗	*	✗	*
	zʐ	✗	*	✗	*
palatal	tɕ	√		√	
	$tɕ^h$	√		√	
	ɕ	√		√	
dorsal	k	✗	Agree[back]:Dor^G	✗	*
	k^h	✗	Agree[back]:Dor^G	✗	*
	x	✗	*	✗	*

Because [k, k^h] are not continuant, the constraint Agree[dist]:$C_{[-son, +cont]}{}^{j}$ is not applicable for [k^j, k^{hj}]. The initial velars [k, k^h] plus [j] groups are still penalized by the [back] agreement constraint: Agree[back]:Dor^G. The constraint in (40) Agree[dist]:$C_{[-son]}{}^{ɥ}$ requires the stops, fricatives and affricates to agree with [ɥ] in distributed values, allowing only [+dist] palatals and sonorants to precede [ɥ]. Comparatively, the initial labials plus the labial glides [ɥ, w] sequences are penalized by the OCP constraint *C^G-Lab^{Lab} (30).

(40) Constraint (anti-OCP):
Agree [dist] : $C_{[-son]}{}^{ɥ}$
The initial obstruents must agree with the following glide [ɥ] in distributed values.

The chart in (39) shows which CG sequences are (dis)allowed in MC, and if those sequences satisfy (cell left blank) or violate (cell includes *) the two new Agree[dist] constraints. Note that even with these two new constraints replacing Agree[back]:$C_{[-son, +cont]}{}^{j}$ and Agree[back]:$C_{[-son]}{}^{ɥ}$, we still need a backness agreement constraint: Agree[back]:Dor^G (as well as *C^G-Lab^{Lab}).

In summary, this section takes an alternative approach to study Mandarin C^G onsets: the front glides [j, ɥ] are regarded as coronals with [-ant, +dist] features. The constraints Agree[dist]:$C_{[-son, +cont]}{}^{j}$ and Agree[dist]:$C_{[-son]}{}^{ɥ}$ are required for Mandarin onsets. However, even with coronal feature agreement constraints, backness agreement is still required for dorsal consonant plus glide sequences. This approach regarding [j, ɥ] as coronals does not improve the Mandarin CG analysis adopted in this paper. On the other hand, as discussed in Section 3–5, using only backness agreement constraints makes the analysis more unified and consistent.

7 Conclusion

In conclusion, the analysis of Mandarin C^G onsets testifies to the necessity of both backness values and articulator features in C^G constraints. The main articulator features (Lab, Cor, Dor) and Duanmu (2000; 2007)'s *Articulator Dissimilation* claim are not explanatory enough for Mandarin onsets. Articulator features and backness values are both needed: *C^G-Lab^{Lab}, Agree[back]:Dor^G, Agree[back]:$C_{[-son]}{}^{ɥ}$ and Agree[back]: $C_{[-son, +cont]}{}^{j}$. Backness agreement may be partially motivated by perceptual similarity and coarticulatory effects involving the active palatal gesture of the following glide. Mandarin requires both OCP and anti-OCP constraints: dissimilation of major articulator features (Lab, Cor, Dor) and agreement of dependent features such as backness, which likely serve to enhance the distinctiveness of phonetic cues and may facilitate ease of articulation. What's more, if we regard the front glides as coronal, the initial dorsal segments and glides are still required to share the same backness value. Therefore, the phonotactic analysis of C^G onsets is more unified with backness agreement constraints.

This study reveals glide asymmetry and asymmetry among obstruents in onset position, providing empirical evidence for the markedness scale and sonority scale within complex onsets. The drive to reduce overall markedness appears to be a key factor underlying the relative scarcity of C + [ɥ] onsets. Glide asymmetry is also attested in other Chinese varieties. Furthermore, backness agreement constraints align with the universal sonority scale principle. Specifically, the constraint Agree[back]: $C_{[\text{-son, } +\text{cont}]}{}^{j}$ restricts and marks only fricative or affricate + [j] sequences, such as *[fʲ], whereas stop + glide onsets, having higher sonority distance, are less marked and therefore more frequent. This obstruent asymmetry can be predicted based on sonority distance between onset constituents. Overall, the asymmetries and C^{G} constraints identified in Mandarin offer fresh insights into universal onset restrictions. The extent to which these findings apply cross-linguistically remains an open question for future research.

Appendices

	p	pʰ	m	f	t	tʰ	n	l	ts	tsʰ	s	ʈʂ	ʈʂʰ	ʂ	ʐ	tç	tçʰ	ç	k	kʰ	X	ŋ	j	w	ɥ
consonantal	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	–	–	–
sonorant	–	–	+	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+
continuant	–	–	–	+	–	–	–	+	±	±	+	±	±	+	+	±	±	+	–	–	+	–	+	+	+
LABIAL	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
round	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
labiodental	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CORONAL	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	–	–	–	–	–	–	–
anterior	0	0	0	0	+	+	+	+	+	+	+	–	–	–	–	–	–	–	0	0	0	0	0	0	0
distributed	0	0	0	0	–	–	–	–	–	–	–	–	–	–	–	+	+	+	0	0	0	0	0	0	0
DORSAL	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+
high	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	+	+	+	+	+	+	+	+
low	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	–	–	–	–	–	–	–	–	–	–
front	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	+	–	–	–	–	+	–	+
back	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	–	–	–	+	+	+	+	–	+	–

Appendix 1: Distinctive Feature Chart of Mandarin Consonants & Glides.

C + ^{j}			*C^{G}-LabLab	Agree [back] : Dor^{G}	Agree [back] : C [-son] ^{ɥ}	Agree [back] : C [-son, + cont] ^{j}
labial	p^{j}	√				
	p^{hj}	√				
	m^{j}	√				
	f^{j}	✗				*
coronal	t^{j}	√				
	t^{hj}	√				
	n^{j}	√				
	l^{j}	√				
	ts^{j}	✗				*
	ts^{hj}	✗				*
	s^{j}	✗				*
	tʂ^{j}	✗				*
	tʂ^{hj}	✗				*
	ʂ^{j}	✗				*
	z^{j}	✗				*
palatal (Cor, Dor)	tç^{j}	√				
	tç^{hj}	√				
	ç^{j}	√				
velar	k^{j}	✗		*		
	k^{hj}	✗		*		
	x^{j}	✗		*		*

Appendix 2: Cj inventory (Mandarin Chinese).

Note: The symbol "✗" indicates that the relevant form is missing.

The symbol "√" indicates that the relevant form is allowed.

The symbol "*" is assigned when there is a violation to a certain constraint.

C + ɥ			***C^{G}-Lab^{Lab}**	**Agree [back] : Dor^{G}**	**Agree [back] : C [-son] ɥ**	**Agree [back] : C [-son, + cont] ^{j}**
labial	pɥ	✗	*		*	
	pʰɥ	✗	*		*	
	mɥ	✗	*			
	fɥ	✗	*		*	
coronal	tɥ	✗			*	
	tʰɥ	✗			*	
	nɥ	√				
	lɥ	√				
	tsɥ	✗			*	
	tsʰɥ	✗			*	
	sɥ	✗			*	
	tʂɥ	✗			*	
	tʂʰɥ	✗			*	
	ʂɥ	✗			*	
	zɥ	✗			*	
palatal (Cor, Dor)	tɕɥ	√				
	tɕʰɥ	√				
	ɕɥ	√				
velar	kɥ	✗		*	*	
	kʰɥ	✗		*	*	
	xɥ	✗		*	*	

Appendix 3. Cɥ inventory (Mandarin Chinese).

C + ^{w}			*C^{G}-Lab^{Lab}	Agree [back] : Dor^{G}	Agree [back] : C [-son] ^{ɥ}	Agree [back] : C [-son, + cont] ^{j}
labial	p^{w}	✗	*			
	p^{hw}	✗	*			
	m^{w}	✗	*			
	f^{w}	✗	*			
coronal	t^{w}	√				
	t^{hw}	√				
	n^{w}	√				
	l^{w}	√				
	ts^{w}	√				
	ts^{hw}	√				
	s^{w}	√				
	$tʂ^{w}$	√				
	$tʂ^{hw}$	√				
	$ʂ^{w}$	√				
	$z_{ʐ}^{w}$	√				
palatal (Cor, Dor)	$tɕ^{w}$	✗		*		
	$tɕ^{hw}$	✗		*		
	$ɕ^{w}$	✗		*		
velar	k^{w}	√				
	k^{hw}	√				
	x^{w}	√				

Appendix 4: C^{w} inventory (Mandarin Chinese).

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Competing interests

The author has no competing interests to declare.

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