Sociophonetic variation in the alveolar lateral in Yami

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This paper examines lateral (/l/) variation in Yami, an indigenous language of Orchid Island, Taiwan. New acoustic evidence on F2–F1 distance and duration shows that palatalized laterals [lʲ] in Yami are characterized by greater formant distance and longer duration. These acoustic correlates are influenced by a mixed bag of social and linguistic factors, indicating the need for a coordinated assessment of these factors. Results also suggest that in general, younger, less-rooted, and Mandarin-dominant speakers have a narrower formant distance and shorter duration, indicating a less palatal-like /l/ pronunciation. The loss of [lʲ] among these speakers may be linked to a rapidly changing linguistic ecology, which fuels cross-linguistic transfer from Mandarin, the language of communication with outsiders. Since [lʲ] only occurs in Yami, younger speakers may have converged towards Mandarin and predominantly use [l]s, leading to a restructuring process in Yami phonology.

Keywords: lateral, palatalized, Yami, language contact, rootedness, linguistic ecology, cross-linguistic transfer

1. Introduction and background

In language contact situations, speakers may incorporate[1] linguistic features from one language to another, causing restructuring of the overall system (Mufwene, 2001, pp. 16–22; Thomason, 2001, pp. 85–88). Yami, a language of the Western Malayo-Polynesian branch of the Austronesian language family (Blust, 2009, pp. 30–31; Ross, 2005) spoken on Orchid Island, Taiwan, has reportedly been

1. While "transfer" can take place bi-directionally in bilingual speech (Mennen, 2004), in this paper, the observed transfer phenomenon refers to cross-linguistic influence of Mandarin on Yami. Also, the outcomes of contact need not be restricted to transfer effects, as the context of contact itself may lead to restructuring of systems in contact (Winford, 2003).

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facing this shift-toward-dominant-language phenomenon (Li & Ho, 1988; Rau, 1995; Lai, 2011). This shift has been attributed to long-lasting Mandarin hegemony and current unstable linguistic ecology on Orchid Island (Lai, 2018; Lai & Gooden, 2022).

This largescale language shift shows different trajectories for phonological variation in the Yami sound system, hinting at the inherent complexity of sound change in language contact situations. One suggests *convergence* towards Mandarin lateral production (Lai & Gooden, 2014; Lai & Hsu, 2013) and the integration of Mandarin yes/no question intonation into Yami (Lai, 2018; Lai & Gooden, 2018a, 2022). Another path of sound change exhibits *maintenance*, with increased use of nucleus raising in Yami /ay/ and /aw/ serving as an ethnic identity marker (Rau, Chang, & Dong, 2009), by which speakers use to articulate "Yaminess" in response to increasing sociocultural conflicts with Mandarin speakers (Lai & Gooden, 2018b).

The overarching aim of this paper is to leverage acoustic analysis of Yami laterals (henceforth, /l/) to augment our understanding of /l/ variation in the context of intense contact with Mandarin. To that end, we provide the first results of an acoustic analysis of Yami laterals. We also examine influences of the local linguistic ecology and various (socio)linguistic factors on the patterns of /l/ variation to corroborate earlier arguments that tie the loss of the Yami /l/-palatalization rule to cross-linguistic transfer from Mandarin (Lai & Gooden, 2014; Lai & Hsu, 2013).

Two sets of analyses were conducted. First, we examined Yami lateral realization by comparing acoustic properties of /l/s before [i] (henceforth, /l/_[i] tokens) with /l/s in other vocalic contexts (henceforth, /l/_elsewhere),[2] to establish whether /l/-palatalization is indeed allophonic and context-driven. Second, we focused the analysis on /l/_[i] tokens as palatalization in this context is an allophonic realization. The goals here were to examine the acoustic correlates associated with a palatalized [lʲ]-like variant, and how or whether these properties are indexed to social categories. Further, given the relatively limited sociophonetic research on variation in low-resource indigenous languages, our results provide important perspectives on variation in non-Western contexts.

The remainder of this section reviews the phonetics of palatal lateral sounds (Section 1.1) and /l/ variation in diverse sociocultural settings (Section 1.2), which provide a backdrop to the discussion of phonetics and variation of /l/ sounds in Yami. Next, we introduce Yami phonology and review phonological context of lateral variation (Sections 2.1, 2.2) and layout research questions and hypotheses (Section 2.3). Section 3 gives a portrait of Orchid Island; Section 4

2. Other vowels include [a], [ə], [o/u], and [aɪ /əɪ], see Section 2.1.

describes the methods; and Section 5 presents acoustic-phonetic details on Yami laterals in two contexts (/l/_[i] and /l/_elsewhere). In Section 6, we focus solely on the /l/_[i] tokens and report how acoustic realization of /l/ is influenced by various (socio)linguistic factors. Section 7 synthesizes the findings, discusses reasons for the loss of /l/-palatalization in Yami, and suggests directions for future research.

1.1 Phonetics of palatalized laterals

Laterals are articulatorily and acoustically complex sounds and are highly variable in production and the associated phonetic properties (Ladefoged & Maddieson, 1996; Lawson, Stuart-Smith, Scobbie, Yaeger-Dror, & Maclagan, 2011; Charles & Lulich, 2019).

Compared to plain laterals, articulation of a palatalized lateral entails greater involvement of the tongue tip and very anterior part of the tongue blade (see Figure 1). Changes in articulation are thus associated with a greater F2–F1 distance. This is evidenced by formant (and spectral) data (Nance, 2014; Nance & Kirkham, 2020) and palatographic evidence (Iskarous & Kavitskaya, 2018).

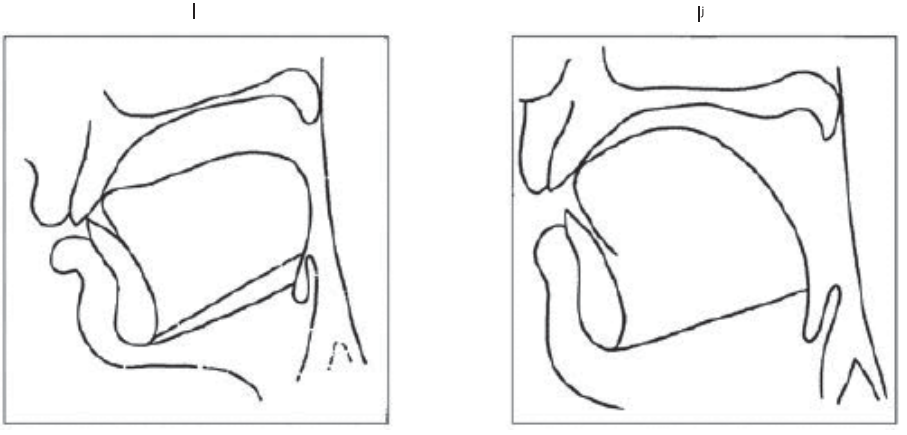


Figure 1. Articulatory structures for [l] and [lʲ] in Russian (from Iskarous & Kavitskaya, 2018, with permission)

In some languages, palatalization is a purely phonetic effect, while in others palatalization is well integrated into the phonological system. Contemporary Scottish Gaelic, for example, has three distinct lateral phonemes: dental velarized lateral /l̪ˠ/,[3] dental palatalized lateral /l̪ʲ/, and alveolar lateral /l/ (P. Ladefoged, J.

3. We retain the symbols used in the original papers.

Ladefoged, Turk, Hind, & Skilton, 1998; Shuken, 1980). Nance (2014) and Nance and Kirkham (2020) found that palatalized /l̪ʲ/s had the highest F2 and lowest F1 of the three laterals, velarized laterals /l̪ˠ/ had the lowest F2 and highest F1, and alveolar laterals had values in between the two.

Research comparing palatalized and non-palatalized consonants is also instructive. For instance, Kochetov (1999) found that in Standard Russian, palatalized consonants had F2 values that were almost double those of plain consonants and were longer overall.

In summary, formant structure is a robust cue distinguishing palatalized sounds from their non-palatalized counterparts. Next, we review sociophonetic effects on /l/ realization across sociocultural contexts.

1.2 /l/ Variation: Scenarios and outcomes

/l/ variation may arise from dialect (Van Hofwegen, 2010) or language (Nance, 2014) contact. Van Hofwegen (2010) reported an apparent-time change in /l/-darkening in Princeville African American English (AAE) (North Carolina), which emerged because of dialect contact with the European American English variety. Specifically, though lighter /l/s once prevailed in earlier AAE varieties, younger AAE speakers have now converged towards the speech of their European American neighbors by using dark /l/s. Nance (2014) reported contact-based variation in contemporary Scottish Gaelic, whose three distinct lateral phonemes /l̪ˠ/, /l̪ʲ/, and /l/ are maintained by older speakers. Younger Glaswegians now produce significantly fewer palatalized /l̪ʲ/, arguably due to close contact with the community-dominant English language, which does not have a phonemically palatalized lateral.

/l/ variation has been also shown to carry socio-indexical functions signaling individual's group affiliation. For instance, Simonet (2010a, 2010b) examined alveolar laterals among two groups of Catalan-Spanish bilinguals (Catalan-dominant versus Spanish-dominant) residing in Majorca. Catalan and Spanish laterals differ in their degree of velarization, ranging from darker Catalan laterals to lighter Spanish laterals. Younger Catalan-dominant female bilinguals interestingly, exhibit a convergence towards a Spanish-like light /l/ production since the use of Catalan dark /l/s is associated with a rural origin (Simonet, 2010a). Welsh-English bilinguals also make strategic productions of /l/s to index their group belongingness. Welsh and the Welsh English variety both have dark /l/s in all syllable positions (Wells, 1982), and folk perceptions reveal a stigma around a Welsh accent (e.g., Garrett, Coupland, & Williams, 1999; Williams, Garrett, & Coupland, 1996). Recent data (Morris, 2017) echo such folk perceptions, showing that Welsh-English female bilinguals are more likely to produce "standard" light

/l/s in their English. This suggests an orientation away from a markedly Welsh accented English.

2. Lateral variation in Yami

This section provides an overview of Yami sound inventory and phonotactics, a more detailed review of Yami lateral sounds, and phonological context of variation. This helps frame our research questions to assess factors influencing phonological variability in /l/ variation.

2.1 Yami phonology: The basics

Yami has twenty consonants (Figure 2), four monophthongs [ɪ, ə, a, o/u],[4] and four diphthongs [aɪ, aʊ, oɪ, iʊ] (Rau & Dong, 2006, pp. 79–81). The diphthongs [aɪ] and [aʊ] are centralized and raised as [əɪ] and [əʊ] respectively, and serve as regional features separating the raising northern dialect from non-raising southern dialects (Lai & Gooden, 2018b; Rau *et al.*, 2009).

	Labial		Alveolar		Retroflex		Palatal		Velar		Uvular	Glottal
Stop	p	b	t			ɖ			k	g		ʔ
Nasal		m		n						ŋ		
Trill				r								
Fricative		v			ʂ						ʁ	
Affricate							t͡ʃ	d͡ʒ				
Liquid				l		ɻ						
Glide		w						j				

Figure 2. Yami consonants (represented in IPA)

The basic syllable structure is (C)V(C). Consonant clusters are allowed only when the onset contains a glide (CG)V(C), for example, [kwat] '*boiling hot*' (Rau & Dong, pp. 82–83). Stress is phonemic in Yami, for example, [mapiŋʂán] '*tasty*' and [mapíŋʂan] '*organized*' (Rau & Dong, 2006, p. 82). The stress defaults to the final syllable and is usually omitted orthographically. For words without final stress, stress is marked individually, as in [apía] '*very good*'. The prefix tey- [təɪ]

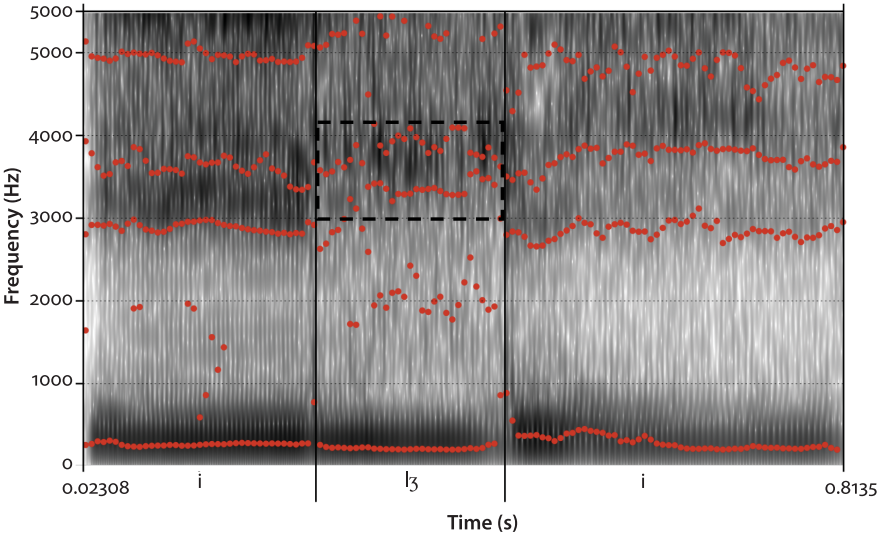
4. [o] and [u] are in free variation.

'most' attracts and shifts stress to the following syllable, such that [təɪ + apía] *'very good'* becomes [təɪápia] *'the best'* (Rau & Dong, 2006, p. 82).

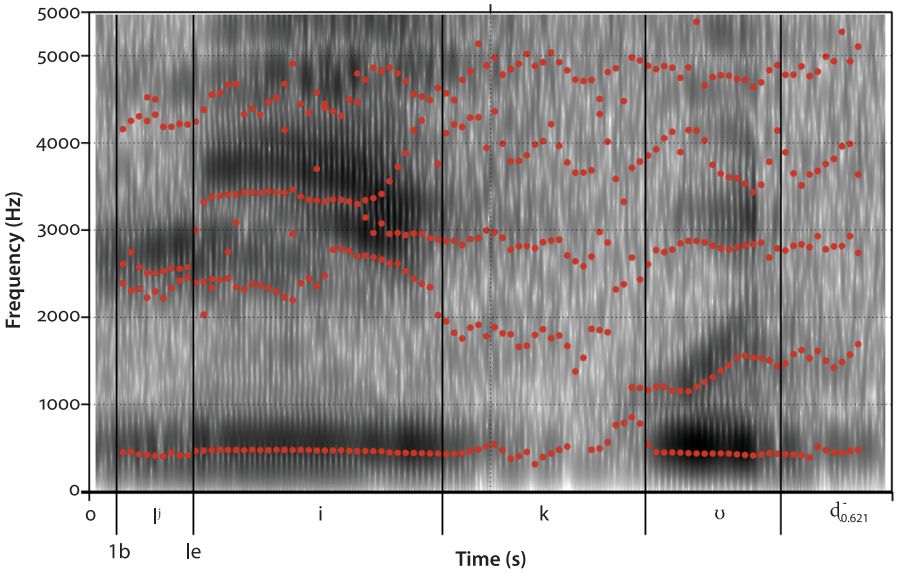
2.2 Yami lateral sounds

Although researchers (Chang, 2000; Ho, 1990; Rau & Dong, 2006) generally recognize two allophones of /l/: a plain alveolar lateral [l] and another before the high front vowel [i], there is no consensus on the precise phonetic categorization of this second allophone. While Chang (2000, p. 44) stated that the alveolar lateral palatalizes in this context (i.e., [lʲ]), Ho (1990) and Rau and Dong (2006, p. 81) described this allophone as an alveolar lateral fricative [ɮ]. Following these latter descriptions, Lai and Hsu (2013) and Lai and Gooden (2014) similarly treated this allophone as an alveolar lateral fricative.

In this study, we revisit our earlier analysis and present a first report of acoustic-phonetic details on the two lateral allophones. Using this analysis, we argue that /l/, in the high front vowel context, is in fact *not* a lateral fricative [ɮ], but a palatalized lateral [lʲ]. In particular, [ɮ] is characterized by audible frication noise throughout with a high-frequency energy at around 3000–4000 Hz (the square in Figure 3a), both of which are missing from the Yami lateral (Figure 3b), but which shows a large difference between F2 and F1, hence a palatalized lateral [lʲ].



a. Glaswegian alveolar fricative lateral in intervocalic context, as in [iɮi] (female speaker, from Lawson, Stuart-Smith, Scobbie, & Nakai, 2018)



b. Yami palatalized lateral as in [lʲikʊd̥] /likod/ *'back'* (female, 52 years old)

Figure 3. Glaswegian alveolar lateral fricative [ɮ] and Yami palatalized lateral [lʲ]

This /l/-palatalization can be viewed as part of a wider coronal palatalization phenomenon before [i] in Yami, affecting also nasals and sibilants, for example, [n] → [nʲ] /___ [i] as in [anʲiɔɪ] *'coconut'* and [s] → [sʲ] /___ [i] as in [asʲisʲi] *'flesh, meat'* (Chang, 2000, pp. 44–45). This is not surprising since coronals are frequent targets of place-changing palatalization induced by an immediately adjacent segment, /i/ or /j/ (Kochetov, 2011).

The patterning of the palatalized allophone in Yami appears to be closely linked to certain social factors. Results from earlier auditory analyses suggest that the palatalized /l/ variant is rapidly falling out of use among younger, infrequent Yami speakers (Lai & Hsu, 2013) and among those who attained a higher education level[5] (Lai & Gooden, 2014; Lai & Hsu, 2013). Since /l/-palatalization is specific to Yami phonology and not seen in Taiwanese Mandarin, both of these earlier studies attributed this sound change to Mandarin influence, predicting that continued diminished use of the palatalized variant would lead to its disappearance from Yami.

Given the wider phenomena of rapid language loss and the dearth of sociophonetic research on Yami, an instrumental analysis of /l/ realization is indis-

5. Mandarin is used as the medium of instruction from preschool to university in Taiwan.

pensable for a more nuanced understanding of Yami lateral sounds and the bounds of variation. In what follows, we layout the research goals and hypotheses of this study.

2.3 Research goals and hypotheses

This paper has two goals. First, we report on an acoustic analysis of Yami laterals, testing the degree of influence of the following vowel on /l/ realization. We examine whether /l/_[i] tokens are acoustically distinct from /l/_elsewhere words or whether /l/ realization is undifferentiated across phonetic contexts. Following the literature on /l/ realizations (Section 1.1), we examine F2–F1 distance and duration to provide some clarity on the precise nature of the two /l/ allophones. Second, we focus attention on the /l/_[i] tokens to explore how /l/ production in this context is affected by (socio)linguistic factors. This analysis offers a lens for learning how the changing linguistic ecology shapes the trajectory and outcome of /l/ variation in Yami.

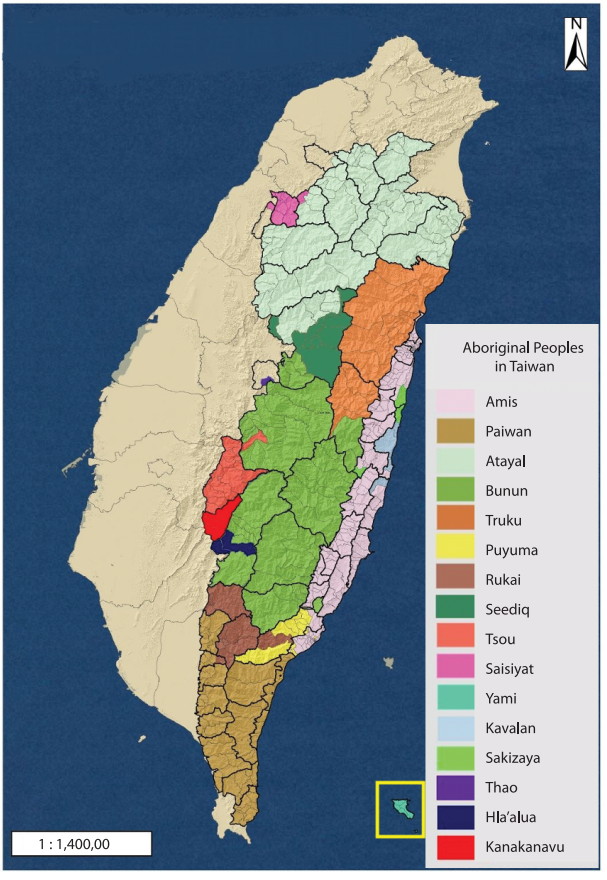
The discussion of lateral sounds (Section 1.1) above suggests we might reasonably expect that, firstly, in Yami, the palatalized lateral [lʲ] will have a higher F2 (hence a greater F2–F1 distance) and longer duration than the plain alveolar lateral [l]. Thus, we anticipate that speakers' lateral realization would vary between /l/_[i] and /l/_elsewhere contexts. Secondly, for /li/ tokens, we expect to see age-related variation in /l/ realization (Lai & Gooden, 2014; Lai & Hsu, 2013), with older speakers being more likely to preserve the Yami-specific palatalization rule and produce palatal-like [l]s than younger speakers. Lastly, we offer supporting arguments for observed changes and link them to cross-linguistic influence from heavy contact with Mandarin. A compelling reason for situating /l/ variation within a contact-induced framework is that while most of our mid-aged and older participants reported Yami as their L1 and primary language by preschool age (Section 4.5.2), there are instances where even fluent Yami speakers have started merging the two lateral allophones. Such variation is hard to explain solely through a language decay model (Dorian, 1981; Sasse, 1992a, 1992b), given speakers' grammatical proficiency.

Section 3 gives an overview of the socioeconomic changes and language contact situation that have impacted the linguistic ecology on Orchid Island to aid our understanding of sociolinguistic variation in /l/ production.

3. Linguistic ecology of Orchid Island

3.1 Social dynamics in Yami society

Taiwan is a multi-ethnic society in which Taiwanese Mandarin, Taiwanese Southern Min, Hakka, sixteen Austronesian (indigenous) and various Southeast Asian languages are spoken. Mandarin has been promoted as the official language since the 1940s, and Yami is an indigenous language spoken on Orchid Island off the southeast coast of Taiwan (yellow square in Map 1). Since both Taiwan and Orchid Island are islands, for clarity, we will refer to Orchid Island as "the island" and the Yami people as "islanders" and refer to Taiwan as the "mainland" and its residents/citizens as "mainlanders".



Map 1. Aboriginal languages of Taiwan (2016)
Source: The Indigenous Historical Justice and Transitional Justice Committee, Office of the President, Taiwan (open source).

Despite its geographic isolation, sociopolitical moves by mainland Taiwan have had a continued influence on Orchid Island and simultaneously on Yami language and society. The modern history of Orchid Island since the late 19th century is marked by three major sociohistorical transitions:

I. **Shielding from the outside world** (1890s-1950s): During this period, Orchid Island was delineated as an indigenous reserve, and one could not arrive there without government permission. Islanders made a living through subsistence farming and/or fishing. In 1945, Mandarin was designated as the official language of Taiwan, which simultaneously suppressed ethnic languages, including the Yami language.

II. **Lure of modernity** (1960s-1990s): From 1967 onward, Orchid Island was opened to the public and integration into wider Taiwan society began. Villages like Imowrod, Iratay, and Yayo, hosts of government agencies, municipal infrastructure and public facilities (Map 2), are considered more modernized and commercialized (Kao, 2012; Lai, 2011; Lai & Gooden, 2018b, 2022; Li & Ho, 1988; Rau, 1995; Rau *et al.*, 2009; Tsai, 2009, pp. 33–36). Speakers from these villages have been undergoing accelerated language loss in addition to exhibiting a higher degree of adaptation to Taiwanese culture (Li & Ho, 1988; Rau, 1995; Tsai, 2009, pp. 33–36). In contrast, Iraralay, Iranmilek, and Ivalino villages, which are distant from the main commercial center, were considered hallmarks of Yami language and culture preservation (Li & Ho, 1988; Rau, 1995). Low income from local fishing and farming industries continued to push outward migration of workers to Taiwan.

III. **From a tiny island to top tourist paradise**: Since the turn of the 21st century, the island has gradually rebranded itself as a seasonal vacation destination. Iranmilek village for example, a place renowned for its coastal scenery and water sports, has transformed into a tourism hot spot (Map 2). As such, tourism has rapidly become the major source of income (Kao, 2012; Lai & Gooden, 2018b, 2022) and the tourism business has effectively repopulated the island by attracting adult Yami returnees alongside an influx of mainlanders to work and live here. This has noticeably shifted the demographics of the island. The latest census (The Department of Household Registration, Taiwan, 2021) shows that non-Yami people now represents 19% of the inhabitants on the island.[6]

6. Total Yami population is 4,783 as of May 31, 2021. The number of current residents on Orchid Island is 5,210, among which 4,198 (81%) are Yami people. Source: Population Statistics of Taiwan, the Department of Household Registration, Ministry of the Interior, Taiwan.

Map 2. Distribution of municipal infrastructure and facilities on Orchid Island[7]
Source: The administrative map of Orchid Island, the Department of Land Administration, Ministry of the Interior, Taiwan (with permission).

3.2 Language contact and sociolinguistic effects

In 1945 a compulsory education system designated Mandarin as the language of instruction on Orchid Island, simultaneously banning Yami from schools. This gave rise to other deep-rooted Mandarin hegemonic practices (1946–1987) including banning ethnic languages in public spaces and delivering most television programs and broadcasts in Mandarin. These efforts were so successful that a speaker's proficiency in "standard" Mandarin pronunciation came to index intelligence and patriotism (Sandel, 2003), and quickly established community-wide Yami-Mandarin bilingualism.

The current tourism explosion has further withered away Yami vitality, since Mandarin as the medium of inter-ethnic communication, is considered the key to economic success (Rau, 1995; Lai, 2018; Lai & Gooden, 2018b, 2022). Locals generally agree that only people over 50 years of age (approximately 1,200 speakers)

7. In 1975, the Taiwanese government selected Ivalino village as a "temporary" low dose radioactive waste repository, during which the Yami people were neither informed nor participated in the policy-making progress. The disposal site was founded in 1979, and the first shipment of nuclear waste arrived in 1981 (see Kao, 2012 and Lai & Gooden, 2018b for detailed discussions).

can still carry on fluent conversation in Yami (*ibid.*). A recent fieldwork survey (Lai, 2018) shows that now only a few domains like rituals and religious settings continue to resist major influence from Mandarin.

4. Methods

4.1 Fieldwork

Data for this study was collected during the summer of 2009 and 2014. The first author (who is Taiwanese) collaborated with members of a Yami family, the Society for Conservation of Lanyu Wildlife and Nature, and three local guides for participant recruitment. These different community stakeholders were important in helping her gain access to speakers and also served as Yami-Mandarin interpreters during interviews with older Yami monolinguals.

4.2 Participants

The two fieldwork projects together yielded 61 participants (34 females and 27 males) aged 26–88 at the time of recording.[8] All participants were born and raised on Orchid Island by Yami parents or relatives. A post-experiment survey was used to gather information about participants' language background, travel history, and rootedness (Appendix A). The survey responses showed that most participants (47) acquired Yami by preschool age. Among these participants, 24 of them still used Yami as the primary language for daily conversations; seven used both Yami and Mandarin in social interactions; and 16 have shifted to using Mandarin on most occasions. The remaining 14 participants either acquired both languages simultaneously or were mainly exposed to Mandarin by preschool age.

4.3 Data elicitation

Thirty-seven participants were recorded in 2009, who completed a picture-naming task as part of a study on language contact and language change (Lai, 2011). Another 24 participants were recorded in 2014 as part of larger projects on Yami prosody (Lai & Gooden, 2015, 2016) and segmental variation (Lai & Gooden, 2018b). These participants completed both a picture-naming task and a modified, conversation-style map task dialogue (Anderson et al., 1991).

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8. Three participants (2 females and 1 male) took part in both projects. Since they completed different tasks for each project, they were treated as "different" individuals in the paper.

The picture-naming tasks elicited words in isolation as participants named pictures appearing on a device. In the map task, the participants worked in pairs – one served as an asker and the other, an instruction-giver. They were instructed to "travel" across the six villages on Orchid Island following a specific order, to find ten differences between their maps (see Lai & Gooden, 2018b). Participants were not informed about the purpose of the study.

All recordings took place in a quiet room in the participants' houses using a digital voice recorder (Sony PCM-M10) and were saved to .wav format (44.1 kHz sampling rate;16-bit resolution).

4.4 Target /l/ words

The target words[9] represent a broad range of semantic domains (Uyeda & Mandler, 1980). Focusing on just /l/s, the segment occurred in syllable onset in word-initial or word-medial syllables. This included /li/ tokens (Table 1), as well as /l/_elsewhere (Table 2).[10]

Table 1. /li/ Tokens

Lexical item	Gloss	Elicitation task(s)
/**l**ima/	*'hand'*	Picture-naming
/**l**ila/	*'tongue'*	Picture-naming
/ta**l**inga/	*'ears'*	Picture-naming
/ko**l**it/	*'skin'*	Picture-naming
/**l**ikod/	*'back'*	Picture-naming
/(so)so**l**i/	*'taro(s)'*	Picture-naming & Map task
/ta**l**ili/	*'top'*	Picture-naming
/kama**l**ig/	*'boat shelter'*	Picture-naming & Map task
/**l**ilisnan/	*'chair'*	Picture-naming & Map task
/**l**ilisnan/		
/Iva**l**ino/	*Village name*	Picture-naming & Map task
/**l**ima/	*'five' (numeric number)*	Picture-naming
/ya**l**ima/	*'five' (physical quantity)*	Map task

9. Note that speakers may produce variants of the same lexical item.

10. As noted above, in Yami, /o/ and /u/ are in free variation. The diphthong /ay/ has two realizations: the unraised variant [aɪ] and the raised form [əɪ] (Lai & Gooden, 2018b; Rau *et al.*, 2009).

Table 1. *(continued)*

Lexical item	Gloss	Elicitation task(s)
/libangbang/ /alibangbang/	*'flying fish'*	Picture-naming
/kagling/	*'goat'*	Picture-naming
/mangali, mikali, kali-in/	*'dig'*	Picture-naming
/lisna/ /omlisna/	*'sit down'*	Picture-naming

Table 2. /l/_elsewhere Tokens

Lexical item	Gloss	Elicitation task(s)
/cinalab/	*'cloud'*	Picture-naming
/(ci)cilat/	*'lightening'*	Picture-naming
/lila/	*'tongue'*	Picture-naming
/rala/	*'blood'*	Picture-naming
/labalak/	*'pavilion'*	Picture-naming & Map task
/tatala/	*'boat'*	Picture-naming & Map task
/volangat/	*'silver helmet'*	Picture-naming
/malavang/	*'white'*	Picture-naming & Map task
/malam/	*'walk'*	Picture-naming
/malalayo/	*'run'*	Picture-naming
/omlavi/	*'cry'*	Picture-naming
/somalap/	*'fly'*	Picture-naming
/magolang/	*'thin, slim'*	Picture-naming
/malas/	*'incorrect, wrong'*	Picture-naming
/Iiraralay/	*Village name*	Picture-naming & Map task
/velek/	*'belly'*	Picture-naming
/kekelean/	*'armpit'*	Picture-naming
/aleleh/	*'mobiles"*	Picture-naming
/Iranmilek/	*Village name*	Picture-naming & Map task
/pilo, atlo, tilo/	*'three' (numeric number)*	Picture-naming

4.5 Data analyses

4.5.1 *Datasets*

Of the initial 1,098 /l/_[i] tokens, 195 were discarded due to background noise. Another five influential data points[11] were deleted due to high residuals and large Cook's distances, leaving 898 /li/ tokens for analysis. The results reported below do not depend on this removal. We also initially extracted 880 /l/_elsewhere tokens, 10 were discarded due to the difficulty in tracing F1 or F2 values, and another five influential data points were removed, leaving 865 tokens for analysis. Of these, 583 (67%) occurred in /l/_[a] context; 181 (21%) in /l/_[ə] environment; 45 (5%) in /l/_[o/u] condition, and 56 (7%) in diphthongal contexts (/l/_[aɪ] or /l/_[əɪ]).

4.5.2 *Variables*

The variables were coded for two linguistic factors (the following vocalic context for all /l/ tokens and word position for /li/ tokens only) and six social factors (age, gender, speaking style, village, language use, and rootedness).

Age: The age variable was divided into three levels (older, mid-aged, younger) to capture differences in people's life experience and language background (Table 3). The older group were above 60 at the time of recording. They grew up in the era when Orchid Island was highly socially isolated. They had little exposure to Mandarin and had spent most of their time residing on the Island, with an average of 1.2 years living in Taiwan. Participants aged between 50–60 were labeled as mid-aged. They completed six-year compulsory education and had spent an average of 9.6 years working and living in Taiwan. Participants under 50 years of age were grouped as younger. They grew up in a time when Orchid Island started connecting to the outside world and spent an average of 11.6 years pursuing higher education and/or employment in Taiwan.

Gender and village: Speakers were grouped according to the village where they spent most of the time from birth to age 15. They were labeled as male or female based on self-reported gender identities.

Speaking style: We also considered variation in speaking style as our previous research found geographically bounded stylistic variation in Yami in nucleus raising in /ay/ and /aw/ (Lai & Gooden, 2018b). Given the study design, we focus only on the macrosocial aspects of stylistic variation. The picture naming task elicited

11. Outliers and influential data points were removed using `influencePlot()` in the `car` package (Version, 3.0–5; Fox & Weisberg, 2019).

words in isolation simulating a word-list style and relatively more formal speech. The map-task dialogue elicited more conversational-style speech.

Language use: Participants were divided into three groups based on their self-reported language usage: (a) Yami-dominant speakers use Yami as the primary language; (b) balanced Yami-Mandarin bilinguals are fluent and frequent users of both languages, and (c) Mandarin-dominant speakers have shifted towards Mandarin in daily conversation.

Rootedness: Speakers in rural communities do not always fit neatly into the social groupings (e.g., socioeconomic status) frequently assumed in studies conducted in urban settings (Lai & Hsu, 2013; Lippi-Green, 1989; Reed, 2016). Reed (2016) for example, found that "rootedness" – assessed by factors such as lifestyle, family ties, and levels of local involvement – can offer a more nuanced account for maintenance or loss of regional features in Appalachian English communities.

Following this, nine modules were created: education level, time in Taiwan, major occupation, religious affiliation, mass media exposure, spouse/partner, and social networks with neighbors, co-workers, and friends. Each module contains several levels, each assigned a score which was then summed to represent each participant's degree of rootedness. A higher score indicates a higher degree of local attachment, with the highest possible score being 26 and the lowest being 0. Across all speakers, the median was 13.[12] Speakers who scored below 13 were labeled as less-rooted, and those scoring equal to or above 13 were labeled as more-rooted (Table 3).

Overall, older and mid-aged speakers are more-rooted than younger speakers, but there is no clear difference between female and male speakers. For language use, two extremes are found: Yami-dominant speakers are more-rooted, whereas Mandarin-dominant speakers are less-rooted, with balanced bilinguals roughly divided into two. For village, more-rooted speakers are from Yayo, Iraralay, and Ivalino, and less-rooted speakers are from Imowrod, Iratay, and Iranmilek.

Table 3. Distribution by rootedness and social factors

Social factor	Levels	Less-rooted (%)	More-rooted (%)
Age	Older ($n=15$)	0 (0%)	**15 (100%)**
	Mid-aged ($n=13$)	2 (15%)	**11 (85%)**
	Younger ($n=33$)	**31 (94%)**	2 (6%)
Gender	Female ($n=34$)	19 (56%)	15 (44%)
	Male ($n=27$)	14 (52%)	13 (48%)

12. We report median because this yields a more balanced distribution between more-rooted and less-rooted speakers.

Table 3. *(continued)*

Social factor	Levels	Less-rooted (%)	More-rooted (%)
Language use	Yami-dominant ($n=24$)	0 (0%)	**24 (100%)**
	Balanced bilingual ($n=9$)	5 (56%)	4 (44%)
	Mandarin-dominant ($n=28$)	**28 (100%)**	0 (0%)
Village	Imowrod ($n=13$)	9 (69%)	4 (31%)
	Iratay ($n=7$)	5 (71%)	2 (29%)
	Yayo ($n=11$)	3 (27%)	**8 (73%)**
	Iraralay ($n=8$)	3 (37%)	**5 (63%)**
	Iranmilek ($n=14$)	11 (79%)	3 (21%)
	Ivalino ($n=8$)	2 (25%)	**6 (75%)**

4.5.3 *Measurements, extraction, and normalization*

Acoustic landmarks were labelled at the beginning and ending points of each lateral (denoted as lb and le respectively in Figure 4), based on auditory impression and visual inspection of waveforms and wide-band spectrograms (Praat version 6.0.43, Boersma & Weenink, 2018). In word-initial position, the beginning marker was placed at the onset of voicing. In word-medial position, the beginning marker was placed at the start of the transition into the lateral, characterized by decreased intensity. For each /l/, an ending point was labeled at the end of the transition out of the lateral where F2 stabilized, and intensity had increased for the onset of the vowel.

Two acoustic parameters, F2–F1 distance and duration, were measured. For **F2–F1 distance**, to minimize coarticulatory effects, F1 and F2 measurements points were set between points (**lb** and **le** marks) 10 ms into and out of the lateral to represent the steady state. Though somewhat arbitrary, this roughly corresponds to the onset and offset of the lateral in Nance (2014). An extraction script was used for F1 and F2 measurements at the temporal midpoint of the lateral steady state. Praat's automatic formant tracker was used with a window length of 0.025s, 30 dB dynamic range, and maximum frequency view range of 5,500 Hz (Van Heuven & Turk, 2021). To normalize the values, all formant measurements were converted to Bark (Z) using Traunmüller's (1990) formula and the F2–F1 difference (i.e., Z2-Z1) was computed.

Duration measurements were taken during the lateral steady state and values were extracted using the same extraction script as above. These measurements were log-transformed (log 10) to reduce or eliminate skewing in their distribution and reduce the effect of any possible outliers (Baayen, 2008, p.92; Rosen, 2005).

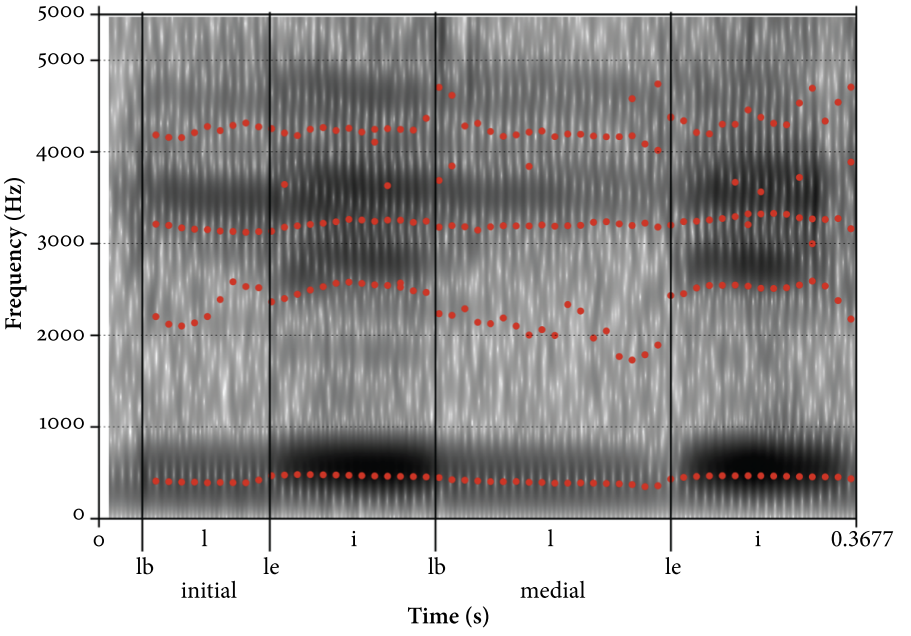


Figure 4. Annotations for /lilisnan/ 'chair' (female, 45 years old)

4.6 Statistical analyses

All statistical analyses were conducted in RStudio (Version 1.3.1073; RStudio Team, 2020). Linear mixed effects regression models (`lme4` package Version 1.1–21, Bates, Mächler, Bolker, & Walker, 2019) were built for F2–F1 distance and duration respectively for laterals in all vocalic contexts (Section 5) and then additional models for laterals in the /li/ context (Section 6.2). The `lmerTest` package (Version 3.1–0, Kuznetsova, Brockhoff, & Christensen, 2019) was used for estimating *p*-values (alpha level set at 0.05). Since the data includes several categorical variables with more than two levels, to arrive at the most parsimonious model, we implemented the (backward) `step` function (Kuznetsova *et al.*, 2019) on a full model. The best models were chosen based on the results of a log-likelihood test (Baayen, 2008). The alpha level for significance was set at $p < .05$, and in addition to reporting *p*-values, we utilized `standardize_parameters()` to compute standardized model parameters (coefficients) as indices of effect sizes (see Kirby & Sonderegger, 2018; Meteyard & Davies, 2020).

Lastly, we used the `ggeffects` package (Lüdecke, 2018) to compute marginal effects which tell us how a change in predictors (independent variables) affects the outcome (dependent variable). Marginal effects should not be confused with the marginal significance of *p*-values. Marginal effects plots were used to visualize the

predicted values for the outcome from the model's statistically significant explanatory variables.

5. Yami lateral realization (all /l/ tokens)

Recalling the first goal of this study, we focus on establishing whether /l/ realization, as measured by F2–F1 distance and duration, is influenced by the quality of the following vowel. We built separate linear mixed effects regression models for F2–F1 distance and duration using all /l/ tokens ($n = 1{,}763$: 898 /l/_[i] and 865 /l/_elsewhere). The models included one linguistic factor (`context`: /l/_[i] versus /l/_elsewhere) and six social factors (`age`, `gender`, `speaking style`, `village`, `rootedness`, and `language use`) as fixed effects, and `word` and `speaker` as random effects. All categorical predictor variables were dummy coded and reference levels set as follows: context (/l/_elsewhere), age (younger), gender (female), speaking style (picture naming), village (Iraralay), rootedness (less-rooted), and language use (Mandarin-dominant).

Results from the final models for `F2–F1 distance`[13] and `duration`[14] are shown in Table 4 and Table 5 respectively, which confirm the expected effects for differences in /l/ production based on phonetic environment (Section 2.3). In the /l/ _[i] context, laterals have greater F2–F1 distance and longer duration, that is, more palatal-like. A variety of social factors were statistically significant (with moderate to strong effect sizes), hinting at the complex nature of this socially constrained variability in Yami /l/ production. Next, we highlight key findings and will turn to a deeper discussion of the effect of social factors in Section 7.

5.1 Formant distance

The results returned two main effects, `gender` and `village`, and a `context*age` interaction for F2–F1 distance. For the `gender` effect, male speakers had a narrower formant distance than females ($\beta = -0.23$, $t = -2.29$, $p = .022$, $R^2 = |0.16|$).[15] The main effect of `village` shows that Imowrod speakers produced a narrower formant

13. The formula for the final model is `Z2_Z1 ~ village + gender + age*context + (1|word) + (1|speaker)`. F2–F1 distance was operationalized as Z2-Z1 (Bark) using Traunmüller's (1990) formula.

14. The formula for the final model is `log_duration ~ gender + village + rootedness + language_use + context*age + (1|word) + (1|speaker)`.

15. All R^2 are reported in absolute values in the text, but the +/− signs are kept in the summary tables.

distance than Iraralay speakers ($\beta = -0.44$, $t = -2.75$, $p = .006$, $R^2 = |0.39|$), while Ivalino speakers in general exhibited a wider formant distance than Iraralay speakers ($\beta = 0.38$, $t = 2.12$, $p = .034$, $R^2 = |0.28|$). The fact that male speakers and those from Imowrod have narrower formant distances indicates a lesser degree of palatality, while a wider distance among Ivalino speakers suggests that they had more palatal-like laterals.

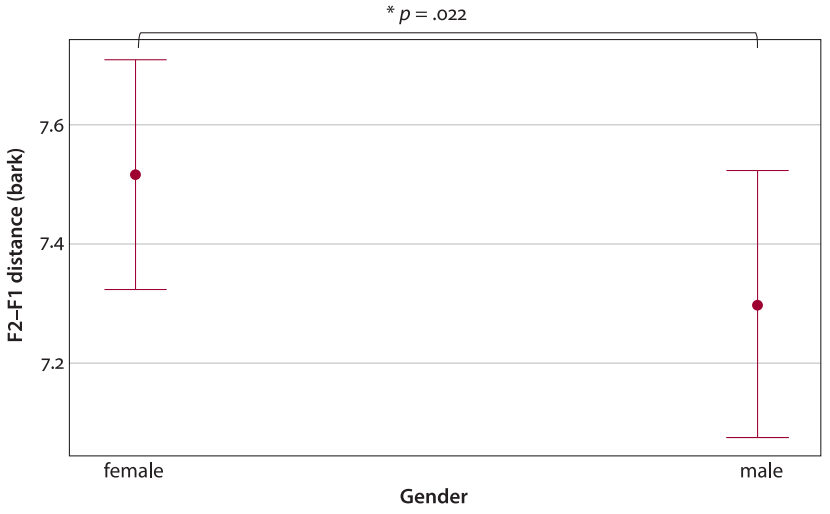
The statistical significance of the interaction term (`context*age`) is because the /l/_[i] tokens produced by older speakers had greater formant distance than the /l/_elsewhere tokens produced by younger speakers ($\beta = 0.84$, $t = 2.85$, $p = .005$, $R^2 = |0.75|$).

Table 4. Summary of linear regression analysis for Yami lateral F2–F1 distance

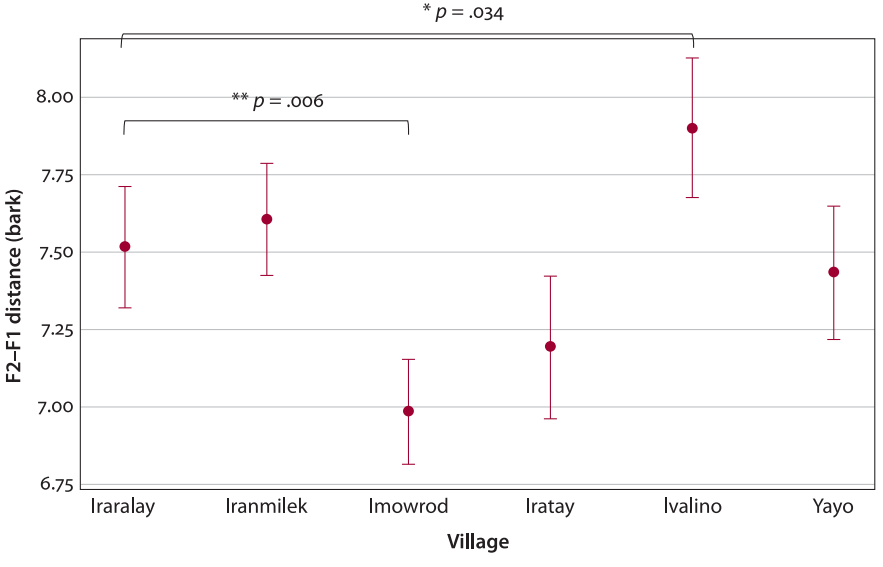
***N* = 1,763**						
Factor	**Level**	***β***	***SE***	***t***	***p***	***R²***
(Intercept)		7.34	0.14	51.76	< 0.001***	0.15
Context	/l/_[i]	−0.29	0.19	−1.56	0.12108	−0.17
Age	Mid-aged	0.16	0.14	1.12	0.263	0.01
	Older	−0.08	0.14	−0.57	0.569	−0.18
Gender	Male	−0.23	0.10	−2.29	0.022*	−0.16
Village	Iranmilek	0.29	0.16	1.78	0.075	0.07
	Imowrod	−0.44	0.16	−2.75	0.006**	−0.39
	Iratay	−0.04	0.20	−0.18	0.857	−0.23
	Ivalino	0.38	0.18	2.12	0.034*	0.28
	Yayo	−0.04	0.17	−0.26	0.798	−0.06
Context*Age	/l/_[i]*Mid-aged	0.56	0.29	1.93	0.054	0.26
	l/_[i]*Older	0.84	0.29	2.85	0.005**	0.75

Significance codes:
*** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$
Indices of effect size for linear regression (Cohen, 1988): $R^2 < 0.02$: Very weak; $0.02 <= R^2 < 0.13$: Weak; $0.13 <= R^2 < 0.26$: Moderate; $R^2 >= 0.26$: Substantial

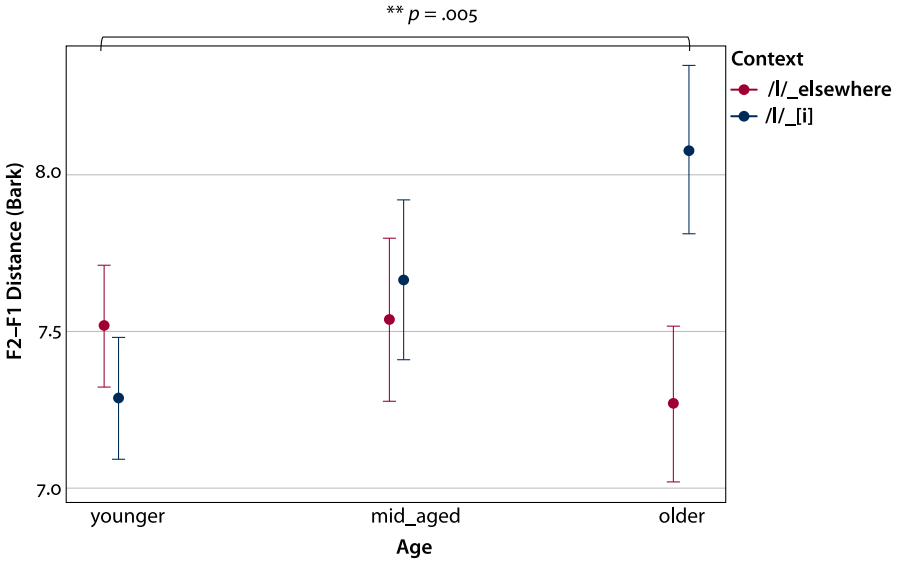
These patterns are visualized in the marginal effects plots (Figures 5a to 5c), displaying the predicted values for the outcome variable (F2–F1 distance) from the model.



a. Predicted gender effect on Yami lateral formant distance



b. Predicted village effect on Yami lateral formant distance



c. Predicted context*age interaction for Yami lateral formant distance

Figure 5. Marginal effects plots for Yami lateral F2–F1 distance (the dots indicate fitted means and the bars indicate limits of 95% confidence intervals)

5.2 Duration

For log-transformed duration, the results returned significant main effects for `age`, `gender`, `village`, `rootedness`, `language use`, and the interaction term (`context*age`), with moderate to strong effect sizes (Table 5).

Among the main effects, mid-aged speakers had longer duration than younger speakers ($\beta = 0.05$, $t = 2.34$, $p = .020$, $R^2 = |0.33|$); male speakers produced shorter duration than females ($\beta = -0.06$, $t = -6.58$, $p < .001$, $R^2 = |0.38|$); Ivalino ($\beta = 0.06$, $t = 3.46$, $p < .001$, $R^2 = |0.36|$) and Yayo speakers ($\beta = 0.03$, $t = 2.18$, $p = .030$, $R^2 = |0.21|$) had longer duration than Iraralay speaker; more-rooted speakers produced longer duration than less-rooted speakers ($\beta = 0.06$, $t = 2.97$, $p = .003$, $R^2 = |0.38|$). Lastly, Yami-dominant bilinguals had shorter duration than Mandarin-dominant speakers ($\beta = -0.12$, $t = -4.64$, $p < .001$, $R^2 = |0.79|$).

The significant `context*age` interaction shows that /l/_[i] tokens produced by older speakers are significantly longer than /l/_elsewhere tokens produced by younger speakers ($\beta = 0.06$, $t = 2.72$, $p = .007$, $R^2 = |0.38|$). The marginal effects plot (Figure 6) reveals that older speakers exploited duration to differentiate /l/_[i]

from /l/_elsewhere tokens, whereas mid-aged and younger speakers did not, thus showing a large overlap between the two categories, (see Figures 6a to 6f).

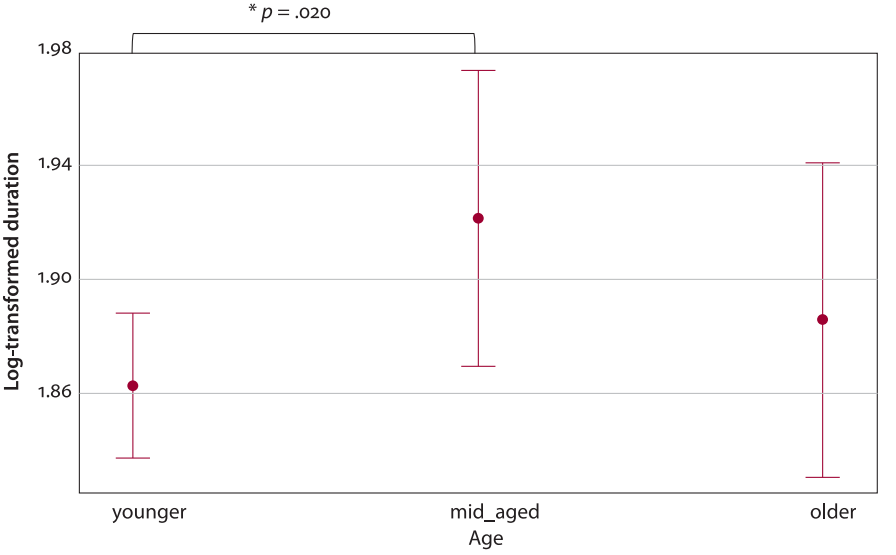
Table 5. Summary of linear regression analysis for Yami lateral log-transformed duration

N = 1,763						
Factor	**Level**	*β*	*SE*	*t*	*p*	R^2
(Intercept)		1.85	0.02	107.215	< 0.001***	0.09
Context	/l/_[i]	−0.01	0.02	−0.65	0.519	−0.08
Age	Mid-aged	0.05	0.02	2.34	0.020*	0.33
	Older	0.01	0.03	0.58	0.562	0.09
Gender	Male	−0.06	0.01	−6.58	< 0.001***	−0.38
Village	Iranmilek	−0.02	0.01	−1.26	0.208	−0.12
	Imowrod	0.01	0.01	1.00	0.320	0.10
	Iratay	−0.02	0.02	−0.94	0.349	−0.11
	Ivalino	0.06	0.02	3.46	< 0.001***	0.36
	Yayo	0.03	0.02	2.18	0.030*	0.21
Rootedness	More-rooted	0.06	0.02	2.97	0.003**	0.38
Language use	Balanced bilingual	−0.02	0.01	−1.06	0.289	−0.10
	Yami-dominant	−0.12	0.03	−4.64	< .001***	−0.79
Context*Age	/l/_[i]*Mid-aged	0.02	0.02	1.07	0.286	0.14
	/l/_[i]*Older	0.06	0.02	2.72	0.007**	0.38

Significance codes:
*** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$
Indices of effect size for linear regression (Cohen, 1988): $R^2 < 0.02$: Very weak; $0.02 <= R^2 < 0.13$: Weak; $0.13 <= R^2 < 0.26$: Moderate; $R^2 >= 0.26$: Substantial

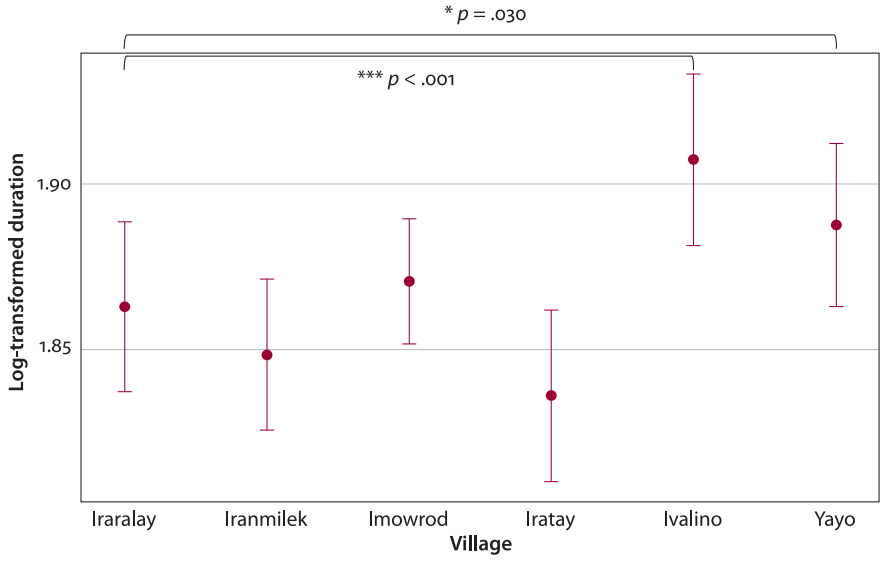
Broadly speaking, these data show that palatalization is best retained by older speakers (over 60 years old) and who are more likely to be Yami monolinguals. A variety of social factors affected /l/ realization – age, gender, village, rootedness, and language use – but a fuller discussion of this is beyond the scope of the paper.

The remaining analysis focuses solely on **/li/** tokens, beginning with a cursory inspection of possible influences of different factors on /l/-palatalization (Section 6.1). Then we conducted statistical analyses to test the extent to which these factors predict /l/-palatalization (Section 6.2).

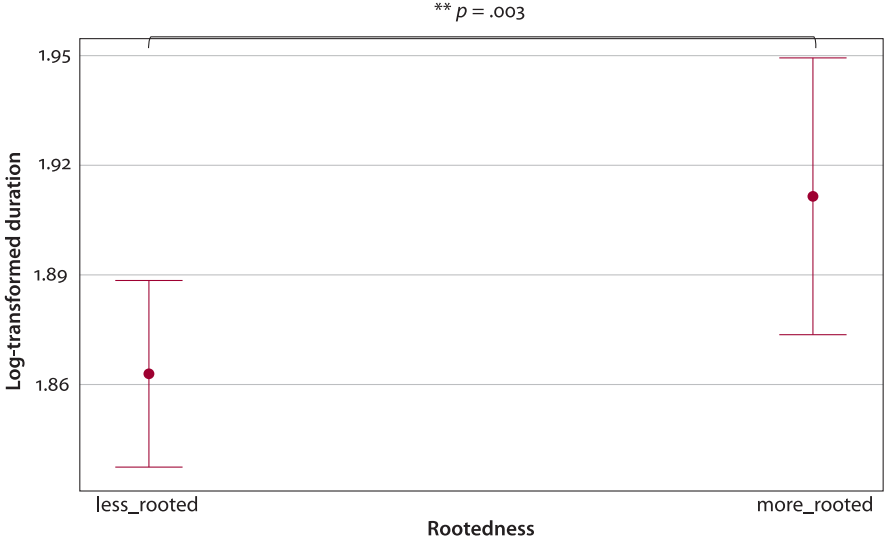


a. Predicted age effect on Yami lateral duration

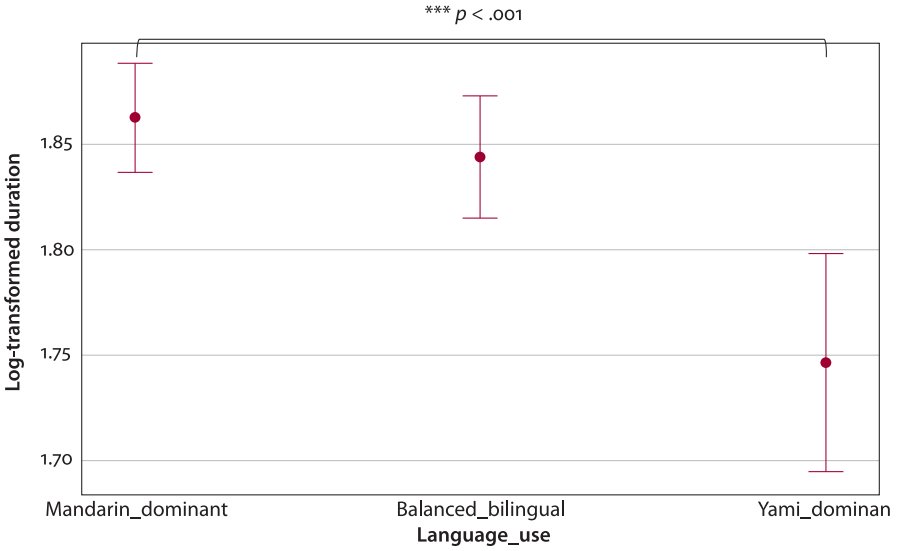
b. Predicted gender effect on Yami lateral duration



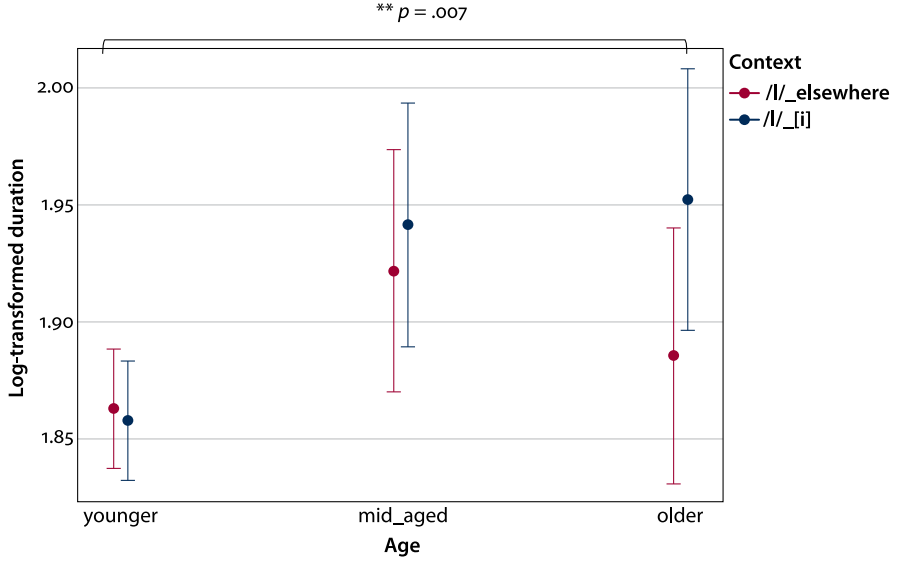
c. Predicted village effect on Yami lateral duration



d. Predicted rootedness effect on Yami lateral duration



e. Predicted language use effect on Yami lateral duration



f. Predicted context*age interaction for Yami lateral duration

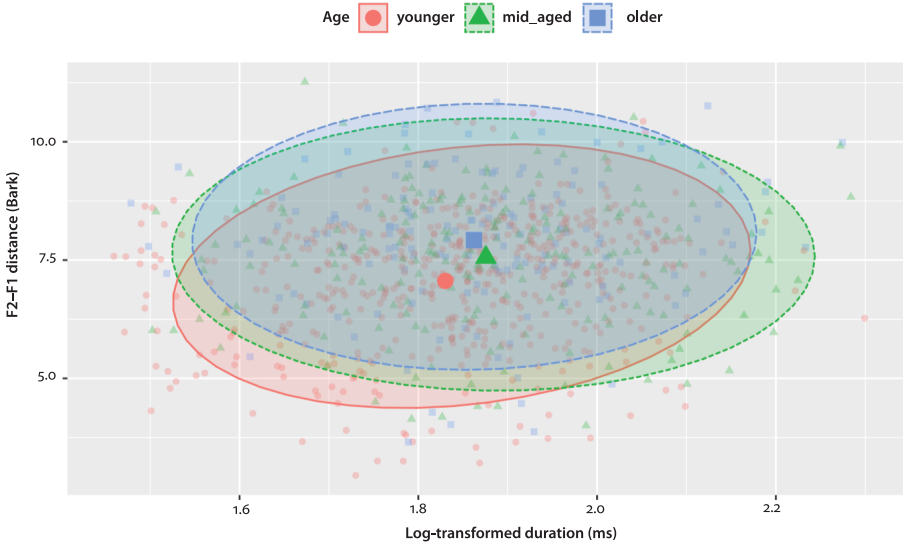
Figure 6. Marginal effects plots for Yami lateral log-transformed duration (dots indicate fitted means; bars indicate limits of 95% confidence intervals)

6. Lateral realization in /l/_[i] context

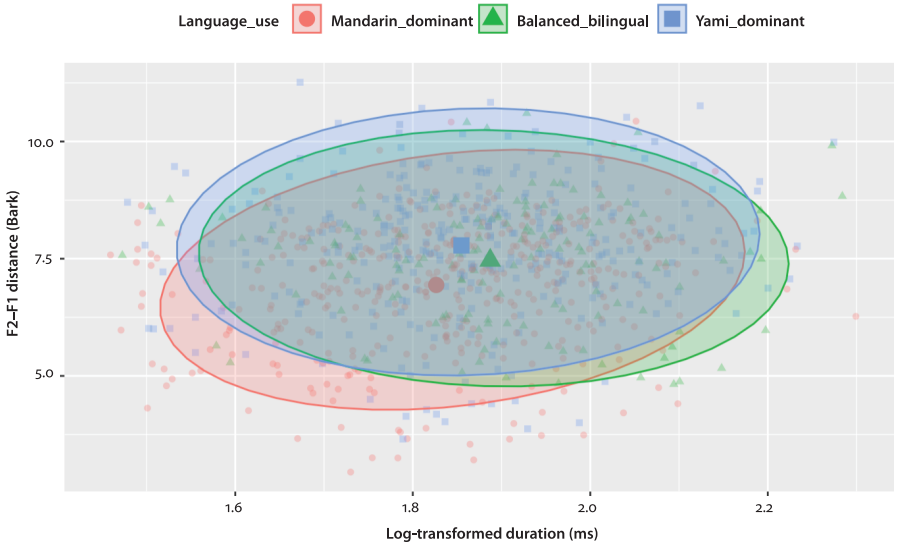
6.1 Overview of variability in /l/-palatalization

While our analysis thus far has established that Yami laterals are palatalized in the high front vowel context, we still do not know if or how /l/-palatalization is socially conditioned. As such, we visualize the distribution of the data points for both acoustic measures (x-axis: duration, y-axis: formant distance) for different groups of speakers (see Figures 7a to 7e). These scatterplots were overlaid with 95% confidence ellipses using the `ggforce` package (Pedersen, 2021) by which we can observe within-group differences (Figure 7).

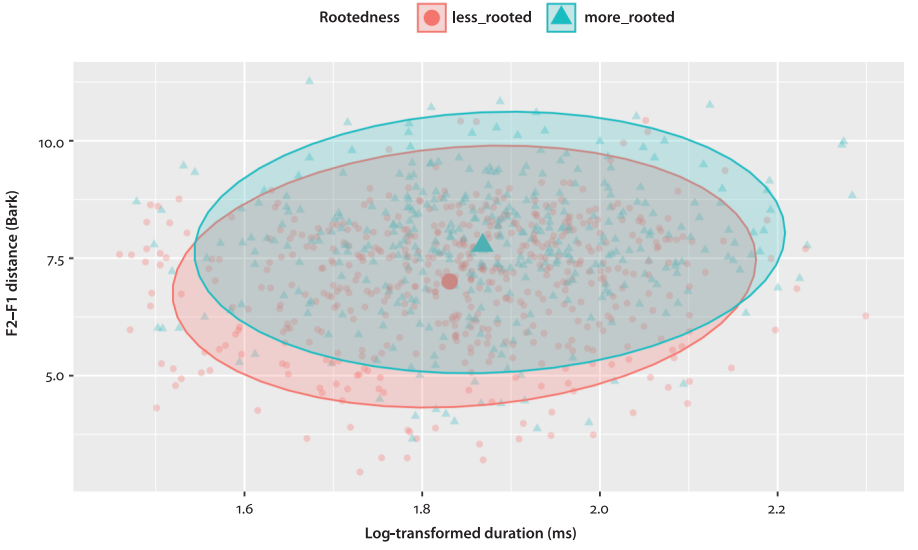
Cursory inspections of these plots suggest group differences for `age`, `language use`, `rootedness`, `gender`, and `village`, but it remains unclear how word position affects /l/-palatalization. For ease of reading, we drew group means, represented by different shapes and colors in the plots. Focusing on social factors, younger, Mandarin-dominant, and less-rooted speakers had narrower formant distances and shorter duration (Figures 7a to 7c), indicating a less palatal-like /l/ pronunciation. We also observed shorter duration by male speakers (Figure 7d) and a complex pattern of variation across the villages. These apparent group differences form the basis for statistical analyses in Section 6.2.



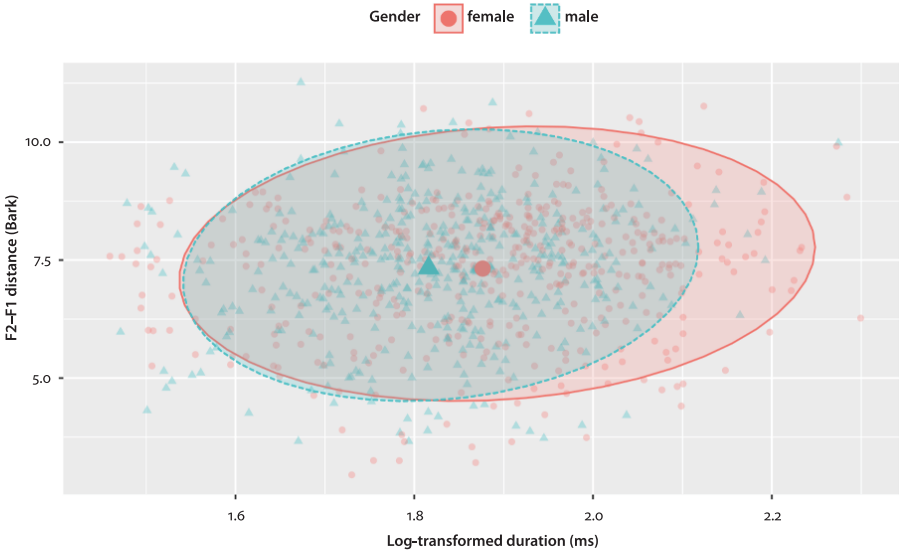
a.


Language_use
Mandarin_dominant
Balanced_bilingual
Yami_dominant
F2–F1 distance (Bark)
10.0
7.5
5.0
1.6
1.8
2.0
2.2
Log-transformed duration (ms)

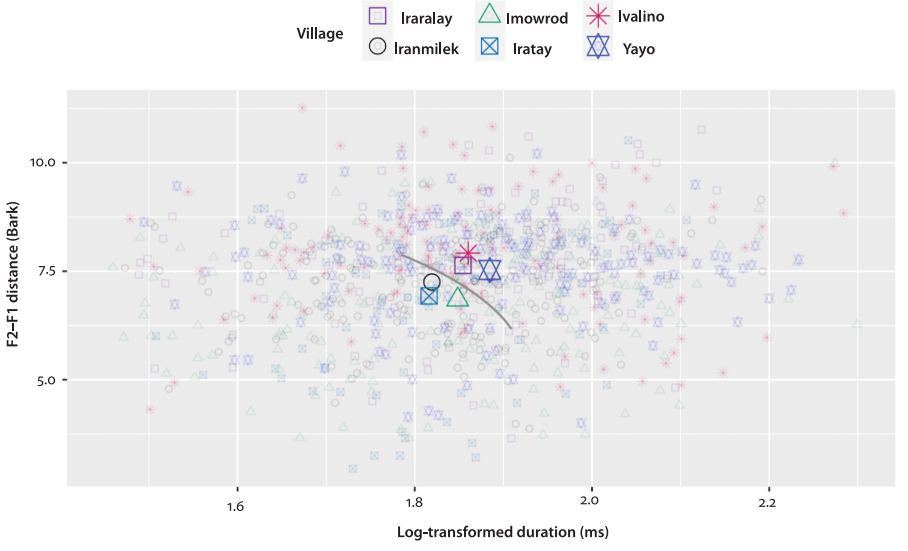
b.


Rootedness
less_rooted
more_rooted
F2–F1 distance (Bark)
10.0
7.5
5.0
1.6
1.8
2.0
2.2
Log-transformed duration (ms)

c.



d.



e.

Figure 7. Scatterplots of Log-transformed duration against F2–F1 distance for age (a), language use (b), rootedness (c), gender (d), and (e) village[16] (ellipsis indicate the limits of 95% confidence intervals)

16. For ease of reading, we did not draw the ellipses for Village, but only plotted group means and manually added a line separating the villages into two broad groups.

6.2 Regression analyses

As before, separate linear mixed effects regressions models were built for F2–F1 distance and duration, which initially included one linguistic (position) and six social factors (age, gender, speaking style, village, rootedness, language use) as independent variables. Word was included as a random effect to account for inter-item variation. Given the age-related effects seen above, we included the interaction term age*village to test for age-related differences as a function of village.

In building the models, all categorical predictor variables were dummy coded and reference levels set as follows: position (word-initial), age (younger), gender (female), speaking style (picture naming), village (Iraralay), rootedness (less-rooted), and language use (Mandarin-dominant).

6.2.1 *F2–F1 distance*

Several social factors were statistically significant (Table 6).[17] First, mid-aged speakers have a narrower F2–F1 distance than younger speakers ($\beta = -1.26$, $t = -3.10$, $p = .002$, $R^2 = |0.91|$). Second, male speakers produced a narrower distance than females ($\beta = -0.25$, $t = -2.42$, $p = .016$, $R^2 = |0.18|$). Third, more-rooted speakers had a greater F2–F1 distance than less-rooted speakers ($\beta = 0.49$, $t = 2.28$, $p = .029$, $R^2 = |0.36|$). Fourth, Imowrod speakers have a narrower formant distance ($\beta = -0.52$, $t = -2.59$, $p = .023$, $R^2 = |0.38|$), whereas Ivalino speakers have a significantly greater formant distance than Iraralay speakers ($\beta = 0.70$, $t = 2.61$, $p = .009$, $R^2 = |0.51|$). Finally, Yami-dominant speakers ($\beta = 0.85$, $t = 3.30$, $p < .001$, $R^2 = |0.62|$) and balanced bilinguals ($\beta = 0.32$, $t = 2.06$, $p = .040$, $R^2 = |0.23|$) produced a greater formant distance than Mandarin-dominant speakers.

We also observed statistically significant age*village interactions, indicating that speaker age by itself is not a sufficient predictor of /l/-palatalization. The mid-aged*Iranmilek interaction reflects the difference in the effect of being mid-aged and from Iranmilek compared to being younger and from Iraralay (reference group). For these mid-aged speakers, /l/s are characterized by a greater formant distance, that is, more palatal-like ($\beta = 1.38$, $t = 3.23$, $p = .001$, $R^2 = |1.01|$). Older speakers from Imowrod ($\beta = 0.78$, $t = 2.01$, $p = .045$, $R^2 = |0.57|$) and mid-aged speakers from Iratay ($\beta = 1.48$, $t = 2.89$, $p = .004$, $R^2 = |1.07|$) also produced a wider formant distance than younger Iraralay speakers. However, older Iratay speakers produced a narrower formant distance (i.e., less palatal-like /l/s) than younger Iraralay speakers ($\beta = -2.61$, $t = -4.88$, $p < 0.001$, $R^2 = |1.89|$). This pattern for older

17. The structure of the final model in lme4 was: Z2_Z1 ~ rootedness + gender + language_use + age*village + (1|word).

Iratay speakers is unexpected and should be treated with caution as there are only 20 data points. A larger dataset is needed to assess the robustness of this pattern.

Table 6. Summary of linear regression for /li/ F2–F1 distance

***N* = 898**						
Factor	**Level**	***β***	***SE***	***t***	***p***	R^2
(Intercept)		7.07	0.20	35.35	< 0.001***	−0.19
Age	Mid-aged	−1.26	0.41	−3.10	0.002**	−0.91
	Older	−0.20	0.34	−0.60	0.551	−0.15
Gender	Male	−0.25	0.10	−2.42	0.016*	−0.18
Rootedness	More-rooted	0.49	0.22	2.28	0.029*	0.36
Village	Iranmilek	−0.08	0.20	−0.38	0.705	−0.05
	Imowrod	−0.52	0.20	−2.59	0.023*	−0.38
	Iratay	−0.34	0.23	−1.50	0.133	−0.25
	Ivalino	0.70	0.27	2.61	0.009**	0.51
	Yayo	0.30	0.27	1.10	0.273	0.21
Language use	Balanced_bilingual	0.32	0.16	2.06	0.040*	0.23
	Yami_dominant	0.85	0.26	3.30	< 0.001***	0.62
Age*Village	Mid-aged*Iranmilek	1.38	0.43	3.23	0.001**	1.01
	Older*Iranmilek	−0.25	0.39	−0.64	0.520	−0.18
	Mid-aged*Imowrod	0.10	0.48	0.21	0.833	0.07
	Older*Imowrod	0.78	0.39	2.01	0.045*	0.57
	Mid-aged*Iratay	1.48	0.51	2.89	0.004**	1.07
	Older*Iratay	−2.61	0.53	−4.88	< 0.001***	−1.89
	Mid-aged*Ivalino	0.27	0.46	0.59	0.554	0.20
	Older*Ivalino	−0.58	0.41	−1.43	0.154	−0.42
	Mid-aged*Yayo	0.02	0.45	0.04	0.967	0.01
	Older*Yayo	−0.53	0.40	−1.29	0.198	−0.38

Significance codes:
*** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$
Effect size interpretation for R^2 (Cohen, 1988): $R^2 < 0.02$: very weak; $0.02 <= R^2 < 0.13$: weak; $0.13 <= R^2 < 0.26$: moderate; $R^2 >= 0.26$: substantial

6.2.2 *Duration*

The results showed five significant main effects (Table 7), along with the interaction term `age*village`.[18] Here the linguistic factor (position) significantly influenced duration as word-medial /l/s are longer than word-initial ones ($\beta = 0.13$, $t = 7.03$, $p < 0.001$, $R^2 = |0.74|$). Second, male speakers had shorter /l/s than female speakers ($\beta = -0.09$, $t = -6.88$, $p < 0.001$, $R^2 = |0.52|$). Third, speakers from Imowrod ($\beta = 0.06$, $t = 2.73$, $p = .006$, $R^2 = |0.37|$) and Ivalino ($\beta = 0.08$, $t = 2.38$, $p = .017$, $R^2 = |0.45|$) had longer /l/s than Iraralay speakers. Fourth, /l/s elicited from the map-task are longer than those from picture-naming task ($\beta = 0.03$, $t = 2.16$, $p = .031$, $R^2 = |0.19|$). Fifth, balanced bilinguals produced longer /l/s than Mandarin-dominant speakers ($\beta = 0.05$, $t = 2.42$, $p = .016$, $R^2 = |0.28|$). The significant mid-aged*Imowrod interaction indicates that mid-aged Imowrod speakers produced shorter /l/s than younger Iraralay speakers ($\beta = -0.17$, $t = -2.87$, $p = .004$, $R^2 = |1.02|$).

Table 7. Summary of linear regression results for /li/ log-transformed duration

***N* = 898**						
Factor	**Level**	***β***	***SE***	***t***	***p***	***R*²**
(Intercept)		1.74	0.03	66.81	< 0.001***	−0.63
Position	Medial	0.13	0.02	7.03	< 0.001***	0.74
Gender	Male	−0.09	0.01	−6.88	< 0.001***	−0.52
Village	Iranmilek	0.03	0.02	1.23	0.218	0.16
	Imowrod	0.06	0.02	2.73	0.006**	0.37
	Iratay	0.02	0.03	0.89	0.372	0.14
	Ivalino	0.08	0.03	2.38	0.017*	0.45
	Yayo	0.03	0.03	0.90	0.371	0.17
Speaking style	Map task	0.03	0.01	2.16	0.031*	0.19
Language use	Balanced_bilingual	0.05	0.02	2.42	0.016*	0.28
	Yami_dominant	−0.01	0.03	−0.19	0.849	−0.03
Age*Village	Mid-aged*Iranmilek	−0.05	0.05	−0.90	0.368	−0.28
	Older*Iranmilek	−0.02	0.05	−0.44	0.660	−0.12
	Mid-aged*Imowrod	−0.17	0.06	−2.87	0.004**	−1.02

18. The formula of the final model in lme4 was: `log_duration ~ position + gender + style + language_use + age*village + (1|word)`.

Table 7. *(continued)*

N = 898						
Factor	**Level**	***β***	***SE***	***t***	***p***	R^2
	Older*Imowrod	−0.07	0.05	−1.46	0.146	−0.41
	Mid-aged*Iratay	−0.12	0.06	−1.94	0.053	−0.73
	Older*Iratay	−0.09	0.07	−1.40	0.163	−0.54
	Mid-aged*Ivalino	−0.05	0.06	−0.80	0.427	−0.27
	Older*Ivalino	−0.10	0.05	−1.96	0.050	−0.58
	Mid-aged*Yayo	0.00	0.05	0.00	0.999	0.00
	Older*Yayo	0.01	0.05	0.15	0.879	0.05

Significance codes:
*** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$
Effect size interpretation for R^2 (Cohen, 1988): $R^2 < 0.02$: very weak; $0.02 <= R^2 < 0.13$: weak; $0.13 <= R^2 < 0.26$: moderate; $R^2 >= 0.26$: substantial

7. Discussion

This study examined sociophonetic variation in the Yami alveolar lateral. We confirmed, contra earlier reports, that the lateral has no fricative component and palatalization occurs only in the /l/_[i] context, as manifested by greater F2–F1 distance and longer duration than in other contexts. Yami /l/-palatalization thus reflects a wider cross-linguistic phenomenon of context-driven palatalization before high front vowels as seen in Standard Russian (Kochetov, 1999). Further, we saw that variability in /l/-palatalization was influenced by a variety of social and linguistic factors (Table 8). Crucially, the influence of these factors differed across the two acoustic properties examined, underscoring the importance of not considering these effects in isolation.

Given these highly complex patterns, we highlight just a few key findings (Section 7.1), discuss catalysts for change and potential implications for the loss of /l/-palatalization in the Yami sound system (Section 7.2), and offer suggestions for future studies (Section 7.3).

Table 8. Summary table of significant factors for /l/_[i] tokens from regression models

Measure / Factor	F2–F1 distance	Duration
Position	not significant (n.s.)	word-medial > word-initial
Age	mid-aged > younger	n.s.
Gender	male < female	male < female
Village	Imowrod < Iraralay Ivalino > Iraralay	Imowrod > Iraralay Ivalino > Iraralay
Rootedness	More-rooted > less-rooted	n.s.
Style	n.s.	map task > picture-naming
Language use	balanced bilingual > Mandarin dominant Yami-dominant > Mandarin dominant	balanced bilingual > Mandarin dominant
Age*Village	mid-aged*Iranmilek > younger*Iraralay older*Imowrod > younger*Iraralay mid-aged*Iratay > younger*Iraralay older*Iratay < younger*Iraralay	mid-aged*Imowrod < younger*Iraralay

7.1 Patterning of /li/ realization

The results show that gender was the most consistent predictor for both acoustic measures as males had a narrower F2–F1 distance and shorter duration, suggesting a less palatal-like pronunciation. This gender effect was previously unreported in Yami segmental (Lai & Gooden, 2014, 2018b; Lai & Hsu, 2013) and prosodic (Lai, 2018; Lai & Gooden, 2018a, 2022) variation research. A tentative explanation for this male pattern could be due to differences in division of labor (see Gal, 1978; Nichols, 1976). In present-day Yami society, men often work as tourist guides and have more face-to-face interaction with Mandarin-speaking tourists. Yami women, on the other hand, are more likely to engage in domestic work or tourist-related services that involve less direct interaction with Mandarin-speaking tourists. The presence of this sound change is worth exploring in future work as part of understanding the association between larger socioeconomic dynamics and language use and variation in Yami.

Second, it appears that /l/-palatalization is predominantly held by Yami dominant, older, and more-rooted speakers, who interestingly employed only the *formant* distance measure. That is, duration played no role in their production. Balanced bilinguals, on the other hand, used greater formant distance and longer duration jointly (i.e., more palatality) than Mandarin-dominant speakers.

Third, we see a solid age effect since mid-aged and older speakers generally exhibited a wider formant distance or longer duration than younger speakers. Critically, this effect intersects with village (age*village). This is consistent with our observation that the rate of language shift differs given on-the-ground linguistic ecological changes that are differentially affecting villages across the island. This might help explain why we also observed unexpected patterns like older Iratay speakers with narrower formant distance than younger Iraralay speakers, and mid-aged Imowrod speakers with shorter /l/s than younger Iraralay speakers. This might be due to rapid language loss in Iratay and Imowrod villages, whereas Iraralay is reported to preserve Yami the best.

Lastly, only the duration measure showed word position and speaking style effects. Since our more proficient Yami speakers did not use duration in palatalized laterals, it is possible that duration is used by speakers when the formant distance property has been lost. In these cases, duration is likely a secondary feature.

7.2 Loss of /l/-palatalization: Catalysts and implications

Since F2–F1 distance and duration were affected by different factors, it is hard to draw precise conclusions about the maintenance or loss of /l/-palatalization in Yami. However, when considering both acoustic measures simultaneously (Section 6.1), some group differences emerged. For instance, younger speakers used less palatal-like /l/s relative to mid-aged and older speakers (Figure 7a). This is consistent with previous findings reporting younger speakers as leaders of sound change. Since speaker age is often intertwined with other social factors, a closer inspection of individual's *language use* and *rootedness* would help provide evidence for/against whether the variation under discussion is a change in progress.

The general trends of /l/-palatalization mirrors language usage patterns in the wider community. It is unsurprising then that Yami-dominant and balanced bilingual speakers produce more palatal-like /l/s, whereas Mandarin-dominant speakers are shifting towards a plain-lateral pronunciation. This resonates with Lai (2018) and Lai and Gooden (2018a, 2022) who showed that speakers' language background plays a vital role in determining the linguistic outcomes in bilingual setting. In these studies, frequent Yami speakers utilize canonical Yami intonation patterns. However, as Mandarin usage and proficiency increase, Mandarin-dominant speakers have gradually integrated Mandarin intonation into their Yami speech.

Rootedness, our measure of the individual's degree of local involvement, was another significant predictor of /l/-palatalization. More-rooted speakers are those who spend the majority of their life on Orchid Island, are involved in non-

tourism-related industries, and have strong network ties with the Yami community. Less-rooted speakers, however, are less attached to the local community, typically having resided in mainland Taiwan for more than a decade before "relocating" to Orchid Island. They also rely on tourism economies and have frequent face-to-face interactions with tourists and Taiwanese friends. These differences are reflected in their linguistic output, with more-rooted speakers having more palatalized productions. This aligns with Reed (2016)'s claim that individuals with a higher degree of local attachment are more likely to preserve regional/traditional features.

It turns out that /l/-palatalization also exhibits regional variation. Overall, speakers from Iraralay, Ivalino, and Yayo produce palatalized /l/s more often than speakers from Imowrod, Iratay, and Iranmilek. The results mimic the general observations that Yami is best preserved in Iraralay and Ivalino villages and is quickly diminishing in Imowrod and Iratay (Li & Ho, 1988; Rau, 1995; Lai, 2011). The decreased use of /l/-palatalization among Iranmilek speakers really caught our attention because Iranmilek's linguistic vitality was third only to Iraralay and Ivalino in earlier reports (Li & Ho, 1988; Rau, 1995). Now Iranmilek speakers are seemingly undergoing a progression toward /l/-depalatalization, likely attributable in part to Iranmilek becoming an emerging commercial center and hot spot for tourists (Section 3.1). Increased contact with Mandarin speakers and thus frequent use of the language are plausibly a driving force for /l/-depalatalization.

Mandarin influence on Yami /l/-depalatalization may also be due to analogy between the two languages. Specifically, both Mandarin and Yami have only one lateral phoneme /l/, which occurs in syllable-initial position[19] and can be followed by different vowels. A fundamental difference is that the /l/-palatalization rule does *not* occur in Taiwanese Mandarin in the /li/ context. Thus, Mandarin-dominant speakers may carry over the sole realization of plain lateral [l] from Mandarin to Yami due to cross-linguistic influence. Since Mandarin is used as a medium for interethnic interaction in the tourist industry, frequent interactions are likely fueling the /l/-depalatalization process in heavy-language-contact villages like Iranmilek.

In short, individuals who are younger, frequent users of Mandarin, have lesser connections with the Yami community, alongside speakers from villages with lower language vitality (Imowrod, Iratay, and present-day Iranmilek) display a tendency of /l/-depalatalization. These findings suggest that the palatalized /l/ variant is an unstable feature in Yami, and the plain lateral is in the process of becoming the predominant or even the sole realization. This sound change, cou-

19. The /l/s in these data all occurred in syllable-initial positions, though in very rare cases, /l/ does occur in coda/word-final positions in Yami.

pled with intonational variation in the speech of younger Yami speakers (Lai, 2018; Lai & Gooden, 2018a, 2022), suggest a restructuring process or reduction in the Yami phonological system.

Although grammar simplification or reduction is not uncommon in minoritized language communities, we argue that the rapid loss of the /l/-palatalization among younger and Mandarin-dominant speakers is due to the changing linguistic ecology on Orchid Island and exemplifies a case of Mandarin-influenced sound change. This echoes the argument that it is difficult to separate the current state of Yami vitality from the influences of Mandarin contact (see Mufwene, 2017).

7.3 Future directions

Three relevant issues are worth pursuing in future work. First, given the relatively small dataset, we could not include all relevant interaction terms in the model. A larger dataset would permit testing of the complex interplay among the various factors, such as village*rootedness and rootedness*language use to augment our understanding of /l/ variation in Yami. Second, since palatalization also affects alveolar nasal /n/ and fricative /s/ before the high front vowel [i] (Chang, 2000, pp. 44–45; Ho, 1990), it would be interesting to see if the depalatalization process is restricted to laterals, or whether the coronal palatalization rule (Kochetov, 2011) is collapsing, resulting in further reduction of the Yami phonological system. Another research gap is the link between linguistic ideologies, ethno-cultural identity, and language variation. Linguistic ideologies are notoriously complex yet important in contact situations (Rodríguez-Ordóñez, 2019). Speakers may take agency in adopting a non-native feature to align themselves with others (Morris, 2017; Simonet, 2010a), or may exploit linguistic variants in interactionally-dynamic ways to construct alignments (Moore & Paul, 2015). For Yami, we found that younger speakers often possess a strong indigenous identity, irrespective of whether they retain Yami linguistic distinctiveness (Lai & Gooden, 2018b) or have shifted towards Mandarin features (Lai & Gooden, 2022). Rodríguez-Ordóñez (2019) suggests that collecting metalinguistic commentary from community members, with the use of experimental approaches would help unpack the way speakers store, retrieve, and process linguistic features and their associated social meanings. These data would permit a more nuanced understanding of how /l/-depalatalization and other sound changes are initiated and ideologically-related in Yami.

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Appendix A. Participants' profile (organized by rootedness, dominant language, and fieldwork project)

Participant ID	Rootedness score	Dominant language	First acquired language	Age	Gender	Village	Time of recording
8	26	Yami	Yami	81	female	Ivalino	2009
16	26	Yami	Yami	79	female	Iranmilek	2009
22	26	Yami	Yami	80	female	Yayo	2009
24	26	Yami	Yami	82	female	Iraralay	2009
27	26	Yami	Yami	81	female	Yayo	2009
29	26	Yami	Yami	75	female	Iratay	2009
18	25	Yami	Yami	82	male	Iranmilek	2009
26	25	Yami	Yami	88	male	Yayo	2009
28	25	Yami	Yami	84	male	Imowrod	2009
7	24	Yami	Yami	80	male	Ivalino	2009
37	24	Yami	Yami	80	female	Ivalino	2009
23	22	Yami	Yami	61	male	Iraralay	2009
35	20	Yami	Yami	56	male	Imowrod	2009
19	19	Yami	Yami	60	female	Imowrod	2009
3	18	Yami	Yami	63	male	Yayo	2009
34	17	Yami	Yami	46	male	Yayo	2009
1	16	Yami	Yami	54	male	Iranmilek	2009
9	16	Yami	Yami	54	male	Iraralay	2009
17	16	Yami & Mandarin	Yami	46	female	Yayo	2009
12	14	Yami & Mandarin	Yami	35	female	Iraralay	2009
30	11	Yami & Mandarin	Yami	47	female	Ivalino	2009
20	11	Mandarin	Mandarin	33	female	Imowrod	2009
33	11	Mandarin	Yami	46	female	Yayo	2009
4	10	Mandarin	Yami	44	male	Ivalino	2009
10	9	Yami & Mandarin	Yami	53	male	Iranmilek	2009
5	9	Mandarin	Mandarin	26	male	Iranmilek	2009
36*[a]	9	Mandarin	Yami	35	female	Iratay	2009
25	8	Mandarin	Yami & Mandarin	40	male	Imowrod	2009
32*	8	Mandarin	Yami & Mandarin	30	male	Iranmilek	2009
2*	7	Mandarin	Yami	40	female	Imowrod	2009
6	7	Mandarin	Mandarin	26	male	Iranmilek	2009
11	7	Mandarin	Mandarin	26	female	Iranmilek	2009
13	7	Mandarin	Yami	37	male	Iranmilek	2009

Appendix A. *(continued)*

Participant ID	Rootedness score	Dominant language	First acquired language	Age	Gender	Village	Time of recording
14	7	Mandarin	Yami & Mandarin	35	male	Imowrod	2009
15	7	Mandarin	Yami & Mandarin	38	male	Imowrod	2009
21	7	Mandarin	Yami & Mandarin	32	female	Iraralay	2009
31	6	Mandarin	Yami	46	male	Iratay	2009
60	20	Yami	Yami	58	male	Ivalino	2014
53	19	Yami	Yami	57	female	Imowrod	2014
61	18	Yami	Yami	51	female	Iratay	2014
39	17	Yami & Mandarin	Yami	51	male	Iranmilek	2014
59	17	Mandarin	Yami	47	female	Imowrod	2014
38	16	Yami & Mandarin	Yami	48	female	Iranmilek	2014
40	16	Yami & Mandarin	Yami	50	female	Yayo	2014
41	15	Yami	Yami	51	male	Yayo	2014
50	13	Yami & Mandarin	Yami	41	female	Iraralay	2014
56	13	Yami	Yami	54	male	Ivalino	2014
57	13	Yami & Mandarin	Yami	52	female	Ivalino	2014
44	12	Yami & Mandarin	Yami	37	female	Iraralay	2014
46	12	Mandarin	Yami	40	female	Iranmilek	2014
55	12	Mandarin	Yami	40	female	Iratay	2014
52	11	Mandarin	Yami	51	female	Imowrod	2014
45	10	Mandarin	Yami & Mandarin	33	female	Yayo	2014
51	10	Mandarin	Yami & Mandarin	35	female	Yayo	2014
54	10	Mandarin	Yami	44	male	Iratay	2014
58	10	Mandarin	Yami	43	female	Imowrod	2014
47	9	Mandarin	Yami	30	female	Iraralay	2014
49*	9	Mandarin	Yami	40	female	Iratay	2014
43*	8	Mandarin	Yami & Mandarin	34	male	Iranmilek	2014
42	7	Mandarin	Mandarin	37	male	Iranmilek	2014
48*	7	Mandarin	Yami	45	female	Imowrod	2014

a. Three participants (*) took part in both the 2009 and 2014 projects.

Abstract (Chinese)

本文探討臺灣雅美（達悟）語的邊音變化。該語言有一般邊音及顎化邊音。語音分析顯示，相較於一般邊音，顎化邊音第一和第二共振峰的間距較遠，且音長較長。社會語音學分析顯示，顎化邊音在年輕、講華語為主的世代正快速流失。該現象可歸因於華語的跨語言影響，日後可能導致雅美（達悟）語音韻系統重整。

關鍵字： 邊音，顎化，雅美（達悟）語，語音接觸，跨語言影響

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