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The nonexistence of the plain bilabial trill phoneme

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Abstract. Phonetic studies of bilabial trills in phonemic systems show that they are preceded immediately by an oral stop closure, e.g., /mbʙ, bʙ, p̪ʙ/. A plain bilabial trill without a preceding oral stop closure /ʙ/ is not known to occur as an individual phoneme in any language. On the contrary, plain apical /r/ and uvular /ʀ/ trill phonemes that lack a preceding oral stop closure occur in many languages. The nonexistence of /ʙ/ is likely due to the fact that it does not meet the specific aerodynamic conditions necessary for its production (Maddieson 1989). In this paper, I examine a crosslinguistic sample of consonant inventories containing both bilabial and apical trills. I find that these inventories show an implicational tendency: For each phoneme containing a bilabial trill, there is usually a corresponding phoneme containing an apical trill that shares the same values for voicing and prenasalization. These phonemes always include an oral stop closure preceding the trill, and they pattern as obstruents. In addition, these consonant inventories usually include a plain apical trill phoneme (which patterns as a sonorant), but lack a plain bilabial trill phoneme. The most common such inventory (e.g., found extensively in Austronesian) includes three trills /mbʙ, ndr, r/, while larger inventories are found in the Democratic Republic of the Congo and South Sudan, e.g., Mangbetu /p̪ʙ, bʙ, mbʙ, t̪r, dr, ndr, r/. While a plain bilabial trill does not emerge due to aerodynamic constraints, resulting in a gap in the system, symmetry appears to favor the emergence of bilabial stop-trill phonemes in languages that have corresponding apical stop-trill phonemes.

Keywords. phonetics; typology; universals; sound change; symmetry; bilabial trills; prenasalization; Austronesian; Central Sudanic; Bantoid; Sino-Tibetan

1. Introduction. Bilabial trills are speech sounds found in about 70 languages worldwide. This count includes cases where bilabial trills are part of phonemes or allophones of other speech sounds. It does not include cases where they are exclusively sound symbolic, where they have become extinct in a language, or where the language itself has become extinct.

There are six regions in the world where phonemes containing bilabial trills are concentrated (cf. Figure 1). These include:

- Manus and Sandaun Provinces in Papua New Guinea (PNG) (at least 16 languages),
- Malakula Island in Vanuatu (at least 15 languages),
- Cameroon and Southcentral Nigeria (at least 11 languages),
- Hunan, Jiangsu, Sichuan, and Yunnan Provinces in China (at least 10 languages),
- Northeastern Democratic Republic of the Congo (DRC) and South Sudan (at least 7 languages), and
- Northwestern Brazil (at least 4 languages).

* I thank participants at LSA 2022 for helpful comments and SIL International for funding. I employ the IPA for transcription, except for [ʀ] to represent the voiceless bilabial trill. This paper is in memory of John Lynch and Robert Blust. Author: Kenneth S. Olson, SIL International (ken_olson@sil.org).

There are also several individual languages geographically separate from these areas of concentration that have phonemes containing bilabial trills. The most robust cases are Nias (Indonesia), Muna (Indonesia), Sangtam (India), and Abkhaz (Georgia).

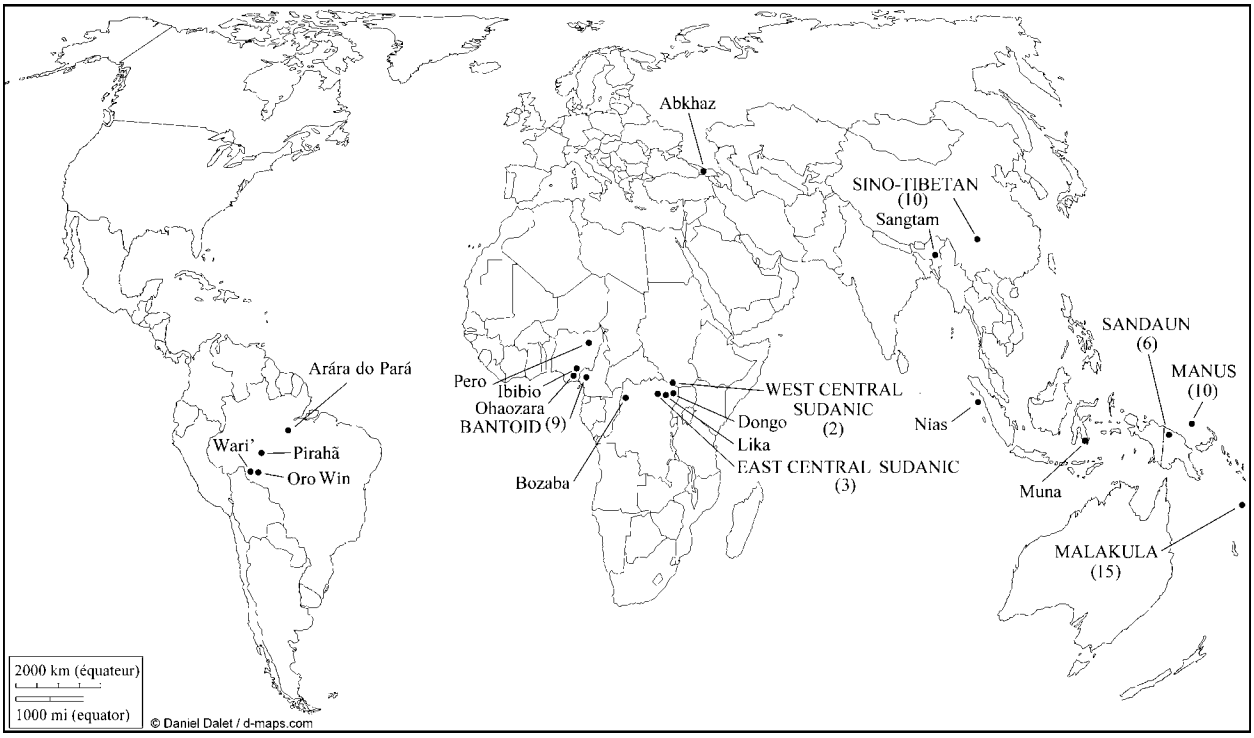

Figure 1. Map of languages with bilabial trills in the core phonology

There is a small but growing corpus of detailed descriptive and acoustic studies on bilabial trills (e.g., Catford 1988, Maddieson 1989, Demolin 1992, Ladefoged & Everett 1996, Ladefoged & Maddieson 1996, Crowley 2006, Blust 2007, Coupe 2015, Olson & Meynadier 2015, Rangelov 2019, Faytak & Akumbu 2021). These studies consistently report that when bilabial trills are part of a phonemic system, they are preceded immediately by an oral stop closure, e.g., /pʙ, bʙ, mbʙ, tʙ, gbʙ/. I follow Ladefoged & Maddieson (1996) in opting for a narrow transcription that makes the oral stop closure explicit.

Significantly, a bilabial trill consonant phoneme without a preceding oral stop closure is not known to occur in any language. That is, /bʙ/ occurs, but not /ʙ/. This differs from apical /r/ and uvular /ʀ/ trill phonemes, which regularly occur with no preceding oral stop closure (Ladefoged & Maddieson 1996:217–230).

In this paper I reserve the term "plain" to refer to a trill that is accompanied by neither prenasalization nor a preceding oral stop closure, e.g., [ʙ, r, ʀ]. This usage differs from some of the previous literature (including my own), in which the term "plain" was employed for trills either with or without a preceding stop closure. By using a narrower transcription, the generalizations of this paper will be much clearer.

Should we construe a stop-trill sequence such as /bʙ/ as a stop with a trilled release [b^{ʙ}] or as a pre-stopped trill [^{b}ʙ]? I will explore this question in Section 7 of this paper, but in the meantime, I will refer to such sounds as *stop-trill phonemes* or *stop-trill sequences*.

The purpose of this paper is to examine a large sample of the consonant inventories of languages containing bilabial trills, with the following questions in mind:

- What consonants (in particular, trills) occur in inventories along with bilabial trills?
- Do these inventories provide crosslinguistic support for the observed patterning mismatch between bilabial and other trills?

This study fills an important gap in the literature, because previous crosslinguistic studies of bilabial trills have mostly focused on the bilabial trills themselves, and have not looked at how they pattern more broadly in the phonological system.

These consonant inventories show an implicational tendency: For each bilabial stop-trill phoneme, there is usually a corresponding apical stop-trill phoneme in the consonant inventory that shares the same values for voicing and prenasalization, e.g., /mbʙ, ndr/. These phonemes always include a preceding oral stop closure. In addition, the consonant inventories usually include a plain apical trill phoneme /r/. There are a couple of exceptions to the implicational tendency, so it cannot be construed as a universal.

In Section 2, I look at cases from Austronesian. In Section 3, I look at cases from the northeastern DRC and South Sudan. In Section 4, I look at cases from Bantoid in Cameroon. In Section 5, I discuss cases where the preceding oral stop closure is apical. In Section 6, I examine Sino-Tibetan languages from China. In Section 7, I summarize the findings and provide evidence that stop-trill phonemes pattern as obstruents. In Section 8, I provide some concluding remarks.

2. Austronesian. In the Austronesian language family, the most common consonant inventory containing bilabial trills includes prenasalized bilabial and apical stop-trill phonemes /mbʙ, ndr/, as well as a plain apical trill /r/, as shown in Table 1:

	Labial	Alveolar
Prenasalized	mbʙ	ndr
Plain	—	r

Table 1. Common inventory of phonemes with trills in Austronesian languages

In this section, I will discuss the consonant inventories in Nias (Indonesia), Kele (Manus Province, PNG), and Neverver and Axamb (Malakula Island, Vanuatu).

2.1. NIAS (INDONESIA). Of the five Nias dialects, two have been examined in some detail in the literature: North Nias (aka Nias Utara) and South Nias (aka Nias Selatan) (Catford 1988, Brown 2001, Yoder 2010.)

The North Nias consonant inventory is shown in Table 2 (Catford 1988). For reasons that will become apparent later, I classify the stop-trill phonemes as plosives. Phonemes containing trills are presented in bold.

	Bilabial	Labiodental	Alveolar	Palatal	Velar	Glottal
Plosive			t		k	ʔ
	b		d		g	
	mbʙ		**nd̻r**			
Fricative		f	s		x	h
	β		z			
Nasal	m		n		ŋ	
Trill			**r**			
Approximant	w		l	j		

Table 2. North Nias consonant inventory (Catford 1988)

North Nias has two stop-trill phonemes /mbʙ/ and /nd̪r/. These are usually prenasalized, but they lose their prenasalization in initial position. A plain apical trill phoneme /r/ is also present.

Catford notes that /nd̪r/ is "post-alveolar (slightly retroflex)" (p. 153). Postalveolar or retroflex apical stop-trill phonemes have been reported in a large number of languages, including Malagasy and Fijian (Ladefoged & Maddieson 1996:131), Mangbetu (Demolin 1991), Nahavaq (Dimock 2009:22), and Axamb (Rangelov 2020:48). This appears to be a widespread phenomenon, and it may in fact be the default articulation for these types of apical sounds. An exhaustive study of this is beyond the scope of this paper, and to my knowledge nothing crucial hinges on this phonetic detail for my analysis. I mention it here as a subject for future research.

In Catford's (p. 153) discussion of /mbʙ/, /nd̪r/, and /r/, he makes a distinction between initiating the trills from an "open" vs. "closed" position. He notes that /r/ starts from an open position, with a narrow space between the tongue tip and the alveolar ridge. The initial closure results from the Bernoulli effect. In such a case, the trill can readily be preceded by a vocalic segment. On the other hand the trill portion of /mbʙ/ and /nd̪r/ starts from a closed position. There is a build-up of pressure behind the stop closure, and the burst of air that results from the release of the stop provides the energy necessary to initiate the trill. I will refer to the preceding oral stop closure as the "initiator" of the trill.

Catford (1982:127) notes that it is possible to initiate a plain bilabial trill [ʙ] from an open position, but—as mentioned above—this does not appear to occur in phonemes containing bilabial trills, likely due to the aerodynamic characteristics of this articulation. My own attempts at producing this articulation require a rather significant amount of airflow in comparison to other speech sounds.

The South Nias consonant system is shown in Table 3:

	Bilabial	Labiodental	Alveolar	Palatal	Velar	Glottal
Plosive			t	tʃ	k	[ʔ]
	b		d	dʒ	g	
	bʙ		**dr**			
Fricative		f	s		x	h
		v				
Nasal	m		n			
Trill			**r**			
Approximant		ʋ	l	j		

Table 3. South Nias consonant inventory (Brown 2001:22, 2005:564)

Once again, we see that the consonant inventory includes both bilabial and apical stop-trill phonemes, as well as a plain apical trill phoneme. Brown notes that /bʙ/ and /dr/ are almost never prenasalized in this variety of Nias. Crosslinguistically, the prenasalized stop-trill phonemes are the most common ones, but the data from South Nias indicates that prenasalization is not obligatory.

2.2. MANUS PROVINCE (PNG). Manus Province consists of a set of islands north of the PNG mainland, the main island being Manus Island. A bilabial stop-trill phoneme /mbʙ/ is attested in Andra-Hus, Kele, Kurti, Leipon, Lele, Nali, Papitalai, Ponam, Sori-Harengan, and Titan (Blust 2007, Keating 2007 and references therein). In these languages /mbʙ/ occurs mostly before /u/, but there is often evidence of contrast with /p/. Table 4 shows the consonant inventory of Kele:

	Bilabial	Alveolar	Palatal	Velar	Glottal
Plosive	p	t		k	ʔ
	pw			kw	
	mbʙ	**ndr**			
Fricative		s			h
Nasal	m	n		ŋ	
	mw			ŋw	
Trill		**r**			
Approximant	w	l	j		

Table 4. Kele consonant inventory (Smythe & Healey 1970, Z'Graggan 1975, Ladefoged, Cochran & Disner 1977, Ross 2002, Blust 2007)

The Kele consonant inventory includes paired bilabial and apical stop-trill phonemes, as well as a plain apical trill phoneme.

As is the case with most Manus languages, Kele lacks a series of prenasalized voiced stops. Blust (2007) notes that Proto-Oceanic *b (which was likely prenasalized) yielded /mbʙ/ before *u in syllable-initial position and /p/ elsewhere. The sound change *mb > mbʙ / __u is widespread in language families with bilabial trills (Demolin 1988, Maddieson 1989, Olson 2015). Proto-Oceanic also had *d and *dr (which I interpret as *nd and *ndr, respectively), both of which were sources for extant /ndr/ in most of the Manus languages with bilabial trills. Other reflexes of *d in Manus languages include /n/, /l/, and /h/.

While the majority of the Manus languages with /mbʙ/ also have /ndr/, the latter phoneme has been lost in Andra-Hus, Ponam, and Sori-Harengan. It appears that the presence of Proto-Oceanic *ndr supported the emergence of /mbʙ/, but once /mbʙ/ emerged, the presence of /ndr/ did not appear to be necessary for the maintenance of /mbʙ/.

2.3. MALAKULA ISLAND (VANUATU). Bilabial trills are common on the southern two-thirds of Malakula Island in Vanuatu. A prenasalized bilabial stop-trill phoneme /mbʙ/ occurs in Aulua, Avava, Axamb, Port Sandwich (Lamap), Neverver, Unua, and Urupiv (Keating 2007; Olson 2015; Rangelov 2019, 2020; Williams 2019). The sound is an allophone of /mb/ in Maskelynes (Healey 2013), Naha'ai (Maddieson 1989), Nati (Lynch 2006), Nahavaq (Keating 2007), Ninde (Murray 2018:18), Nisvai (Jocelyn Aznar, p.c.), Niviar (Keating 2007), and Vivti (Keating 2007).

The Neverver consonant inventory is shown in Table 5:

	Bilabial	Alveolar	Palatal	Velar
Plosive	p	t		k
	mb	nd	ndʒ	ŋg
	mbʙ	**ndr**		
Fricative	β	s		ɣ
Nasal	m	n		ŋ
Trill		**r**		
Approximant	w	l	j	

Table 5. Neverver consonant inventory (Barbour 2012:24)

As we saw in Nias and Kele, the Neverver inventory includes bilabial and apical stop-trill phonemes, and a plain apical trill phoneme. In addition, Barbour (2012:29) attests a voiceless

bilabial trill that patterns as an allophone of /p/. This allophone also occurs optionally in at least one lexical item in Avava (Crowley 2006:28, 37, 164).

Barbour transcribes the phonological rule for the voiceless bilabial trill /p/ → [ʙ̥] / __ u. Barbour doesn't delve into the detailed phonetics of the sound, but given the acoustic assessment of the sound in nearby Axamb (Rangelov 2019), I surmise that the voiceless bilabial trill in Neverver is likely preceded by an oral stop closure. If this is the case, the rule would be written /p/ → [pʀ] / __ u.

The Axamb language, also spoken on Malakula Island, provides an interesting comparison with Neverver. The consonant inventory for Axamb is shown in Table 6.

	Bilabial	Labiodental	Alveolar	Palatal	Velar
Plosive	p		t	tʃ	k
	mb		nd		ŋg
	pʀ				
	mbʙ		**ndr**		
Fricative			s		x
		v			
Nasal	m		n		ŋ
Trill			**r**		
Approximant	w		l	j	

Table 6. Axamb consonant inventory (Rangelov 2019, 2020)

In addition to the three expected phonemes /mbʙ, ndr, r/, there is a voiceless bilabial stop-trill phoneme /pʀ/ that has emerged in the language. This additional phoneme is also attested in Port Sandwich (Lamap) (Williams 2019).

The emergence of /pʀ/ in these two languages is somewhat surprising, as there are two factors militating against it. First, the aerodynamic conditions are not as favorable to its emergence as for /mbʙ/ (Maddieson 1989). Second, there is no corresponding voiceless apical stop-trill phoneme /tr̥/ that would encourage its emergence due to symmetry.

That being said, the presence of /mbʙ/ works in its favor. I suggest that the emergence of /pʀ/ is a relatively recent change, *p > pʀ / __u, encouraged by the comparable change *mb > mbʙ / __u mentioned in Section 2.2.

3. Northeastern DRC and South Sudan. In the northeastern part of DRC and in South Sudan, we find languages that have a larger number of trills in their inventory. The majority of the languages are in the Central Sudanic branch of Nilo-Saharan: Mangbetu, Lombi, Asoa, Baka, and Morokodo (Keating 2007 and references therein). In addition, there is one Bantu language, Lika (de Wit 2010), and one Ubangian language, Dongo (Pasch 1986:179–180), in the region that have bilabial trills. The Mangbetu consonant system is shown in Table 7 below.

In the Central Sudanic languages discussed here, there are typically three sets of plosives—voiceless, voiced, and prenasalized. As we see in the table, the trills in Mangbetu also exhibit these three manners of articulation as well. Each of the three bilabial stop-trill phonemes is accompanied by an apical stop-trill phoneme. In addition, a plain apical trill /r/ is present. The language has a robust labiodental flap /ѵ/, but no plain bilabial trill phoneme.

One added complication is the presence in some of these languages of a labial-velar oral stop closure preceding the trill. These are shown in Table 8 below.

Baka (Parker 1985, Sampson 1997), Morokodo (Persson 2001, 2004), and Lika (de Wit 2010) each have labial-velar stop-trill phonemes *instead* of bilabial ones. Lombi (Kutsch Lojenga 2013) has labial-velar stop-trill phonemes *in addition* to bilabial ones. To my knowledge, Lombi's inventory of 10 phonemes containing trills is the largest that has been attested.

	Bilabial	Labiodental	Alveolar	Palatal	Velar	Labial-velar	Glottal
Implosive	ɓ		ɗ	ʄ			
Plosive	p		t	tʃ	k	kp	ʔ
	b		d	dʒ	g	gb	
	mb		nd	ndʒ	ŋg	ŋgb	
	pʀ		**t̪r**				
	bʙ		**d̪r**				
	mbʙ		**nd̪r**				
Fricative		f	s				h
		v	z				
Nasal	m		n	ɲ	ŋ		
		mv	nz				
Trill/flap		ⱱ	**r**				
Approximant			l	j		w	

Table 7. Mangbetu consonant inventory (Demolin 1990, 1991, 1992; McKee 1991; Larochette 1958; Olson & Mbiri 2013)

	Labial	Alveolar	Labial-velar
Voiceless	pʀ	t̪r	kpʀ
Voiced	bʙ	dr	gbʙ
Prenasalized	mbʙ	ndr	ŋgbʙ
Plain	—	r	—

Table 8. Stop-trill phonemes found in northeastern DRC and South Sudan languages

4. Bantoid. A bilabial stop-trill phoneme /bʙ/ is attested in two Narrow Grassfields languages in Cameroon: Ngwe (Njika 1991) and Medumba (Olson & Meynadier 2015). In addition, bilabial trills are allophonic (sometimes optional) in Babanki (Kejom), Kom, Kuk, Mfumte, Mungaka, Oku, and Vute (Hyman 1980, 2014; Tadadjeu & Sadembouo 1984; Maddieson 1989; Pius Akumbu p.c., Matthew Faytak p.c., Cameron Hamm p.c., Larry Hyman p.c., Greg McLean p.c., Jim Roberts p.c., Adam Shank p.c., Dave Thormoset p.c., Rhonda Thwing p.c.).

The Ngwe consonant inventory is shown in Table 9 below. As shown in the table, the phonemes /bʙ/ and /r/ occur in Ngwe. Examples of words containing /bʙ/ include [lə-bʙə̀] 'tadpole', [à-bʙə̄] 'ashes', [à-bʙə̀ʔ] 'the remains', [lə-bʙə̀ʔ] 'act of remaining', [bʙə̀hā] 'burst it!' (Njika 1991, Maddieson 1989).

Other stop-trill sequences can be derived given certain conditions. A prenasalized bilabial stop-trill sequence [m̩-bʙ] results from the noun class prefix /m̩-/ being juxtaposed with a noun root beginning with /bʙ/, e.g., [m̩̀-bʙī] 'tadpoles' (Njika, p. 20). This contrasts with [m̩̀-bī] 'a dog'.

A prenasalized apical stop-trill sequence [n̩-dr] results when a [d] is epenthesized between a syllabic nasal /Ń-/ and a root beginning with /r/. This can be formalized as Ø → [d] / N̩+__r (Njika, p. 39). For example, [lə-rɔ̀] 'a fight' vs. [ń̩-drɔ́] 'to fight'.

	Bilabial	Labiodental	Alveolar	Palatal	Velar	Labial-velar	Glottal
Plosive	p		t		k	kp	ʔ
	b				g	gb	
	bʙ		**[dr]**				
Affricate		pf	ts	tʃ	kx		
				dʒ			
Fricative		f	s				h
		v	z		ɣ		
Nasal	m		n	ɲ	ŋ		
Trill/flap			**r**				
Approximant			l	j		w	

Table 9. Ngwe consonant inventory (Dunstan 1964, Maddieson 1989, Njika 1991)

In the related language Babanki (Kejom), a syllabic bilabial trill [ʙ̩] is an optional allophone of [ʉ]. Faytak & Akumbu (2021:336) note, "The sequence /bʉ/ is sometimes produced as [bʙ̩]…The trill is debatably an allophone of the vowel rather than the consonant…" We will see more examples of syllabic bilabial trills in Section 6.

5. Apical initiator [t]. So far, we have seen that the oral stop closure preceding a bilabial trill can be bilabial [pʀ, bʙ, mbʙ] or labial-velar [kpʀ, gbʙ, ŋgbʙ]. In anticipation of Section 6, I point out here that there are a significant number of languages where the initiator is apical.

Ladefoged & Everett (1996) document a stop-trill sequence [tʀ] in Wari' and Oro Win in Brazil. Coupe (2015, 2020) documents /tʀ/ and /tʀʰ/ in Sangtam (India), where the contrast between the two phonemes is a matter of voice onset time.

Abkhaz (Georgia) has three phonemes which researchers analyze as alveolar stops with labialization: /tʷ', tʷ, dʷ/ (Catford 1982:146, Hewitt 2004:43). When labialization accompanies velar or uvular stops, it is realized as lip rounding. But when it accompanies alveolar stops, labial-alveolar stops result: [tp', tp, db]. These can be optionally accompanied by a bilabial trill release. The descriptions suggest the following transcription: [tpʀ', tpʀ, dbʙ]. This pattern was also attested in the now-extinct language Ubykh.

6. China: Sino-Tibetan. Several languages in the Hunan, Jiangsu, Sichuan, and Yunnan Provinces of China have a syllabic bilabial trill allophone [ʙ̩]. These include Xiang Chinese (Firth & Rogers 1937), the Sūzhōu variety of Wu Chinese (Faytak, Kuo & Wang 2019), Nuosu (Northern Ngwi) (Keating 2007, Edmondson, Esling & Lama 2017), and several northeast Tibeto-Burman languages: Central Bai (Edmondson, Esling & Li 2021), Ersu (Chirkova et al. 2015), Namuyi (Lama 1994, cited by Chirkova & Chen 2013), Narua (Michaud 2008), Naxi (Michailovsky & Michaud 2006), Northern Pumi (Jacques 2011), and Shuhi (Chirkova 2012). There are likely more.

Most of these languages have phonemes that are referred to as "fricative vowels," and are typically transcribed /ɣ̩, z̩/.

In most cases, the syllabic bilabial trill [ʙ̩] is an allophone of the fricative vowel /ɣ̩/ following bilabial stops (P), coronal stops (T), or both, e.g., /ɣ̩/ → [ʙ̩] / {P, T}__. Examples include [pʙ̩, pʰʙ̩, bʙ̩, tʙ̩, tʰʙ̩, dʙ̩]. Table 10 summaries their occurrence.

Initiator	Languages
{P, T}___	Nuosu, Ersu, Namuyi, Narna, Shuhi
P___	Naxi, Northern Pumi, Xiang Chinese, Sūzhōu Chinese
T___	Central Bai

Table 10. Initiators for [ʙ̩] allophone of /ṿ/.

7. Discussion. To summarize our discussion so far, we have seen that a plain bilabial trill phoneme /ʙ/ has not been attested in any language. Rather, when a bilabial trill occurs in a phoneme, it is preceded by an obligatory preceding oral stop. This preceding oral stop serves to initiate the bilabial trill that follows it, and it can be one of several stops. The places of articulation of the initiating stop that have been attested include bilabial /pʀ, bʙ, mbʙ/, labial-velar /kpʀ, ɡbʙ, ŋgbʙ/, and alveolar /tʀ/. Likewise, syllabic bilabial trills are also preceded by initiating stops [pʙ̩, pʰʙ̩, bʙ̩, tʙ̩, tʰʙ̩, dʙ̩].

We have also seen that bilabial stop-trill phonemes tend to co-occur with apical stop-trill phonemes with the same manner of articulation characteristics. In most cases, the presence of a bilabial stop-trill phoneme implies the presence of an apical stop-trill phoneme, e.g., /mbʙ/ > /ndr/. Contrarily, the opposite does not hold: an apical stop-trill phoneme often occurs without a corresponding bilabial one. There are a number of languages in Austronesian for which this is the case, including Malagasy and Fijian (Ladefoged & Maddieson 1996:131)

Besides the paired stop-trill phonemes, a plain apical trill phoneme /r/ usually occurs in the consonant inventories as well.

In discussing Nias, Catford (1988:154) suggests that /mbʙ/ and /ndr/ arose from a common process. Maddieson (1989:111) argues against this, saying, "[T]he occurrence of (post)alveolar trills in Oceanic languages is not correlated with occurrence of bilabial trills." We can now say that the opposite is true: the occurrence of bilabial trills *is* correlated with the occurrence of apical trills. This is the case not just in Oceanic languages, but in most occurrences of bilabial trills that has been documented worldwide.

Now we can come back to another question that this study has raised: Do bilabial stop-trill phonemes generally pattern as obstruents or as sonorants? In other words, are they best construed as stops with a trilled release (e.g., [bᴮ]) or as pre-stopped trills (e.g., [ᵇʙ])? Multiple examples suggest that they pattern as obstruents.

First, voiced stops and stop-trill phonemes are often both prenasalized in the same consonant inventory. In this study, we've seen this in Neverver, Axamb, and Mangbetu, and it is the case in many more languages.

Second, bilabial stop-trill phonemes often pattern as allophones of stops, e.g.:

- /p/ → [pʀ] / __u
- /mb/ → [mbʙ] / __u

Third, Demolin (1988:69–70) suggested that the bilabial trills in the Mangbetu and related languages derived historically from bilabial stops. Olson (2010) provides additional data to support this hypothesis:

- *p > pʀ / __u
- *b > bʙ / __u
- *mb > mbʙ / __u

Olson suggests that the prenasalized stop-trill phoneme /mbʙ/ was likely the first of the three to emerge. The other two then following suit in order to maintain symmetry in the consonant system.

Fourth, bilabial trills are somewhat unstable in the sense that they "fail" to be produced on a regular basis. This could be due to the narrow aerodynamic conditions necessary for their production. When they fail, they are usually replaced by a fricative, so that the realization of the phoneme is an affricate. This has been attested in multiple languages, including Nias, Wari', Ngwe, and Northern Sangtam.

Fifth, when bilabial trills are lost in a language, they are usually replaced by an obstruent. For example, in Northern Sangtam, younger speakers are replacing /tʙ/ with /t/ and /tʙʰ/ with /tʰ/ (Coupe 2015, 2020). Similarly, in Wari', younger speakers are replacing /tʙ/ with /t/ (Everett & Kern 1997:385). In Aulua, younger speakers are replacing /mbʙ/ with a bilabial stop, and in Neverver, younger speakers are replacing the [ʙ] allophone of /p/ with [p] (Keating 2007:29–31).

Sixth, stop-trill phonemes tend to copy the patterning of plosives in consonant inventories. For example, in Mangbetu, both plosives and stop-trill phonemes contrast with each other with respect to voicing and prenasalization. In Sangtam, plosives, affricates, and stop-trill phonemes all have a two-way contrast with respect to voice onset time. Table 11 presents the consonant system of Northern Sangtam:

	Bilabial	Labiodental	Alveolar	Retroflex	Palatal	Velar	Glottal
Plosive	p		t	ʈ	c	k	ʔ
	pʰ		tʰ	ʈʰ	cʰ	kʰ	
Affricate			ts		tʃ		
			tsʰ		tʃʰ		
Prestopped trill	**tʙ**						
	tʙʰ						
Fricative		(f) (v)	s		ʃ	x	h
Nasal	m		n		ɲ	ŋ	
Trill			**r**				
Approximant			l	ɹ	j		

Table 11. Northern Sangtam consonant inventory (Coupe 2015, 2020)

Given the gaps in the inventory, and given the phonetic similarity of affricates and stop-trill sequences, the "Affricate" and "Prestopped trill" rows could be conflated, yielding a more symmetric inventory.

Taking all this into consideration, I would argue that crosslinguistically bilabial stop-trill phonemes pattern as obstruents, and that they are best construed as stops with a bilabial trill release. A transcription that makes use of superscript characters makes this clearer, e.g., [pᴮ, bᴮ, ᵐbᴮ].

8. Conclusion. The findings in this paper exemplify the interplay between cognitive/distinctive features and physical constraints. On the one hand, the lack of a plain bilabial trill is a gap in these phonemic systems and is likely due to the aerodynamic constraints suggested by Maddieson. At the same time, we see a tendency toward symmetry, as each bilabial stop-trill phoneme has a corresponding apical one.

In short, phonological models that rely on cognitive/distinctive features capture gross categories, while physical factors, such as articulatory effort, aerodynamic constraints, or physiological impossibility (IPA 2005) can capture the finer details (cf. Ohala 1981).

The finding that a plain bilabial trill phoneme does not occur in any language may be a bit uncomfortable for the Council of the International Phonetic Association. One of the key principles for the addition of a sound to the IPA chart is the phonemic principle—that a sound occur as a phoneme in at least one language (IPA 1999:160). This could be an argument for removal of [ʙ] from the IPA chart, or perhaps its conversion to a superscript character [ᴮ] and movement to the diacritics section of the chart. On the other hand, the symbol has proven useful, particularly for representing syllabic trills in Sino-Tibetan. Such decisions must be weighed and considered. I present this paper in hopes that it may provide some guidance for future research on this set of sounds.

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