THE BLURRING HISTORY OF INTERVOCALIC DEVOICING

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ABSTRACT The intervocalic position favors voicing in stops. Yet, some languages have been reported to feature the opposite (unnatural) process of intervocalic devoicing. This paper investigates two such case studies. Pre-Berawan intervocalic *b and *g have developed into Berawan [k] (Blust, 2013; Burkhardt, 2014). Pre-Kiput intervocalic *g, *ɟ͡ʝ, and *v have developed into Kiput [k], [c͡ç], and [f], respectively (Blust, 2002). In Berawan (but not in Kiput), the development of intervocalic devoicing resulted in an unnatural gradient phonotactic restriction. To account for the data, we invoke Beguš's (2018, 2019) *blurring process* model of sound change. The model proposes that unnatural phonology derives from a sequence of at least three phonetically motivated sound changes. We show that the steps involved in intervocalic devoicing are (i) the intervocalic fricativization of voiced stops, (ii) devoicing of fricatives, and finally (iii) the occlusion of devoiced fricatives. Each of the steps is independently attested and articulatorily motivated. Moreover, our *blurring process* proposal explains aspects of the historical development unaccounted for by previous approaches (Blust, 2005). We also present new evidence suggesting that a single sound change could not have operated in the pre-history of Berawan. Thus, we maintain that all unnatural phonology arises from a sequence of phonetically grounded sound changes through the *blurring process*.

1 INTRODUCTION

Unnatural phonological processes are processes that operate against a universal phonetic tendency (Beguš, 2018, 2019). Their existence has far-reaching consequences, as it bears on open questions in phonological theory and linguistic diachrony, such as (i) To what degree is phonology influenced by phonetics (Hayes, 1999)? (ii) How powerful is the phonological computation (Reiss, 2018)? (iii) What constraints or rules are needed in the grammar (Hyman, 2001)? (iv) What is the right theory of sound change and how does sound change operate (Beguš, 2022)? and (v) Is phonological typology primarily influenced by historical (channel bias) or cognitive (analytic bias) factors (Moreton, 2008)? As such, unnatural processes have received considerable attention in phonological literature (Beguš, 2019, 2022; Blevins, 2004; Blust, 2005; Kiparsky, 2008).

In this paper, we investigate two putative cases of *intervocalic devoicing* (henceforth IVD), an unnatural process whereby a voiced consonant becomes voiceless between vowels in a daughter language. The majority of work on unnatural processes that target feature voice focus on final (de)voicing (Blevins, Egurtzegi, and Ullrich, 2020; Kiparsky, 2006, 2008; Yu, 2004) or postnasal (de)voicing (Beguš, 2019; Coetzee and Pretorius, 2010; Hyman, 2001). Intervocalic devoicing has received substantially less attention in previous literature.

More specifically, we focus on two case studies of intervocalic devoicing in Berawan and Kiput. In dialects of Berawan, some instances of intervocalic [k] can be constructed to Pre-Berawan *b and *g. In Kiput, some instances of intervocalic [k], [c͡ç], and [f] can be reconstructed to Pre-Kiput *g, *ɟ͡ʝ (*j), and *v (*w), respectively. Thus, both languages seem to show the unnatural change of IVD. Moreover, Berawan (but not Kiput) shows a synchronic gradient phonotactic restriction against intervocalic voiced stops.

To account for the patterns seen in Berawan and Kiput, we detail a historical development of intervocalic devoicing in the two languages. We demonstrate that intervocalic devoicing operates not as a single unnatural sound change, but results from a sequence of three natural changes. We build on Beguš's (2018, 2019, 2022) model of historical change and propose that intervocalic devoicing arises from the *blurring process*, which follows the general schema in (1). (Thus, while we use the descriptive term *intervocalic devoicing* to refer to a set of empirical facts throughout the paper, we ultimately argue that intervocalic devoicing is never a single sound change.)

(1) Blurring process (Beguš, 2018, 2019)
  i. A set of segments enters complementary distribution.
  ii. A sound change occurs that operates on the changed/unchanged subset of those segments.
  iii. Another sound change occurs that blurs the original complementary distribution.

Our account successfully captures previously intractable aspects of the data set, providing strong support for a model where unnatural-looking diachronic developments (and their phonologizations) result from sequences of phonetically natural changes.

2 INTERVOCALIC DEVOICING AS UNNATURAL

Following Beguš (2018, 2019), we define an unnatural process as a process that operates against a universal phonetic tendency. Natural phonetic tendencies are (i) phonetically grounded in the mechanics of speech production, (ii) cross-linguistically common, and (iii) can result in common phonological processes. The definition of a natural phonetic tendency is restated in (2). The definition of an unnatural phonological process is restated in (3).

(2) Universal phonetic tendency (definition) (Beguš, 2019, p. 691)
Universal phonetic tendencies are phonetic pressures motivated by articulatory or perceptual mechanisms that passively operate in speech production cross-linguistically and result in typologically common phonological processes.

(3) Unnatural phonological process (definition) (Beguš, 2019, p. 692)
An unnatural phonological process operates against a universal phonetic tendency.

Intervocalic devoicing operates against the pressure to voice intervocalic consonants. Intervocalic voicing is a passive tendency that is typologically very common and has a clear phonetic motivation. Thus, intervocalic devoicing fulfills all criteria to qualify as an unnatural process under our definition.

Intervocalic voicing is well attested—the survey in Kaplan (2010) and Gurevich (2004) shows that 26 of 153 (or 17%) languages surveyed feature intervocalic voicing as a synchronic alternation. Intervocalic voicing is also well attested as a sound change: the survey in Kümmel (2007) reports over 15 languages with intervocalic voicing as a sound change. In fact, voicing is the most common form of intervocalic stop lenition, followed by spirantization, approximantization, and others which are less common (Kaplan, 2010).

Moreover, there exists a clear articulatory phonetic motivation for intervocalic voicing. The difference in subglottal and supraglottal pressure is greatest in the intervocalic position and is considerably smaller in the initial or final position. Westbury and Keating (1986) argue that voiced stops will be preferred in the intervocalic position and dispreferred initially or finally because a pressure difference is crucial for voicing. Intervocalically, voiced stops are articulatorily easier to produce than their voiceless counterparts; any neutralization in the opposite direction (from the expected) would result in "added articulatory cost" (Westbury and Keating, 1986, p. 153).

Kaplan (2010) also argues in favor of a perceptual motivation for intervocalic voicing. Invoking Steriade's (2001) P-map, Kaplan claims that intervocalic voicing is the most common type of lenition (more common than spirantization and approximantization) precisely because perceptual differences between voiced and voiceless stops intervocalically are the smallest (i. e. smaller than perceptual differences between intervocalic voiceless stops and voiceless fricatives). Speakers then choose the minimal perceptual difference to repair the phonotactic restriction against intervocalic voiceless stops. Finally, intervocalic voicing is a passive phonetic tendency—stops feature more voicing into closure intervocalically compared to other positions (Davidson, 2016; Docherty, 1992; and literature therein).

In sum, intervocalic voicing has all the characteristics of a universal phonetic tendency. Intervocalic devoicing directly defies this tendency. Thus, according to our definitions (2-3), intervocalic devoicing is an unnatural phonological process.

3 BERAWAN DIALECTS

The Berawan dialects are a group of closely related dialects that belong to the Berawan-Lower Baram group of North Sarawakan languages of the Malayo-Polynesian (Austronesian) language family (Blust, 1992). Blust (1992) identifies four dialects of the Berawan dialect group: Long Terawan (LTn), Batu Belah (BB), Long Teru (LTu), and Long Jegan (LJ). They are spoken by approximately 3,600 speakers around the Tutoh and Tinjar tributaries of the Baram River (Blust, 1992; Lewis, Simons, and Fennig, 2015).

3.1 *Historical developments*

According to the description in Burkhardt (2014), the Berawan dialects feature two series of stops: voiced and voiceless, both unaspirated.[1] Blust (2013) and Burkhardt (2014) report that an unnatural sound change, the intervocalic devoicing, took place in Berawan: Pre-Berawan *g and *d between vowels both devoice (and velarize) to [k] in Berawan. Alveolar stops do not devoice, but undergo intervocalic lenition to [r] (Burkhardt, 2014, p. 249).[2]

Sound change	PMP/Pre-Berawan	Batu Belah
*b > k / V _ V	*abiəŋ	akiŋ
	*bibi	biki
	*bəlibiəw	bəlikiəw
	*bibuj	bikuj
	*dibiən	dikin
*g > k / V _ V	*bigiu	bikiw
	*gigiəq	gikiʔ
	*magi	maki
	*igiəŋ	ikiŋ
	*ugat	ikit

Table 1: Examples of intervocalic devoicing in Berawan (data from Blust, 2013; Burkhardt, 2014).

The list in Table 1 offers an illustration of intervocalic devoicing, but is far from exhaustive. In fact, IVD in Berawan is well-documented and almost exceptionless. A comprehensive study of Berawan dialects in Burkhardt (2014) includes between 425 and 466 vocabulary items for each of the four languages and Pre-Berawan reconstructions for each cognate (489 in total). Based on our counts, *b or *g appears intervocalically in 36 of these reconstructed words, and in all 36 cases, the Berawan dialects show a voiceless stop, the regular reflex of *b and *g in intervocalic position.[3]

In contrast to the intervocalic position, *b and *g remain unchanged in the initial position. There are 46 reconstructed words with initial *b in Pre-Berawan. In all but one word the initial *b remains unchanged.[4] A similar distribution holds for the velar voiced stop in the initial position as well: *g is reconstructed in twelve lexical items of Pre-Berawan and in all of them

1 The analysis in Burkhardt (2014) is based on recordings made using a Sony Minidisc recorder and further analyzed with Toolbox software (Burkhardt, 2014, pp. 36–8).

2 Proto-Malayo-Polynesian *ʀ and *g developed to *g in Pre-Berawan (Burkhardt, 2014) and this change is applied to the reconstructed forms for the purpose of clarity.

3 Long Terawan undergoes further changes that do not interact with our analysis (see Burkhardt, 2014).

4 In the one exception, devoicing occurs initially in all four dialects: *bəlippiəŋ > pəlipiŋ. According to Burkhardt (2014, p. 144), this development is sporadic in a word that already exhibits another sporadic development: degemination of -pp-. There is only one other example in which devoicing initially occurs only in Long Terawan: *buraq > [purǎh] (Burkhardt, 2014).

voicing is retained. (There is only one case of sporadic devoicing in Long Terawan.) Table 2 lists some examples of initial voiced stops in Pre-Berawan and Berawan.

PMP/Pre-Berawan	Batu Belah
*gəm	gəm
*gigun	gikuŋ
*gimot	gimok
*bitok	bitok
*buliən	bulin
*busak	busek

Table 2: Initial voiced stops (data from Blust, 2013; Burkhardt, 2014).

A peculiar fact about the diachronic development of Berawan is that, while velar and bilabial stops undergo devoicing, alveolars undergo lenition in the same word-internal position. Pre-Berawan voiced alveolar stop *d remains a voiced stop initially, but develops to [r] word-internally. The summary of the developments is given in Table 3.[5]

The simplest interpretation of the Berawan developments is an unnatural sound change of intervocalic devoicing (Blust, 1992, 2005). In Section 5, we will summarize previous accounts

5 In addition to the unexpected medial devoicing, there is another quite natural type of devoicing operating in Berawan: devoicing of voiced geminates. Because geminates only appear intervocalically, this devoicing change is seemingly restricted to intervocalic position as well. Geminate devoicing, however, is well-motivated as a context-free sound change. Since voicing is articulatorily difficult to maintain during the closure due to decreased airflow (Ohala, 1983, 1997), and geminates have longer closures, voiceless geminates are universally preferred over voiced ones. Berawan geminates arose after schwa, from consonant clusters, and after “h-accretion”: addition of [h] at the end of words which caused the shortening of vowels and consequently lengthening of consonants (Burkhardt, 2014, pp. 260, 282–286). Some examples of the development of geminates are given in (i). Unlike simple alveolar stops, geminate alveolar stops did undergo devoicing (ic).

(i) Origins of geminates in Berawan
  a. *bunbun > *bubbun > buppuŋ
  b. *tagʀaŋ > *taggaŋ > takkiŋ
  c. *m-iddəm > mittăm

Geminate devoicing, too, contributes to the restriction against intervocalic voiced obstruents, precisely because geminates surface only intervocalically. However, because geminate devoicing is not unnatural and because voiceless geminates are preferred to voiced ones in all positions, we do not consider geminate devoicing to be a case for or against unnatural sound change, and we will not discuss these cases any further.
Labial geminate stops arising after schwa and from consonant clusters do not undergo a change in place of articulation (unlike simple stops), e. g. *təbu > *təbbu > [təppu], *mə-bənnən > *mə-ppənnən > *ppənnən > [pənnən] (after the loss of *mə- and initial degemination) or *əbbis > *əppiq > [piʔ] (after the loss of initial schwa and initial degemination). Geminates arising via “h-accretion”, however, do undergo a change in place of articulation: they develop to voiceless velar geminate stops. The relative chronology of gemination and devoicing is difficult to establish. We have two possible scenarios: either (i) gemination precedes devoicing (*tuba > *tuga > *tuggah > [tukkih], argued for in Burkhardt, 2014), or (ii) devoicing precedes gemination (*tuba > *tuga > *tukah > [tukkih]). Because the exact development cannot be reconstructed or is at best based on relative chronology, we will not discuss the geminate cases any further.

PRE-BERAWAN	BERAWAN	
	# _	V _ V
*b	b	k
*d	d	r
*g	g	k

Table 3: Summary of developments in Berawan.

and review evidence in favor of the hypothesis that a single unnatural sound change is responsible for each of the unnatural trends presented. In Section 6, we will point to intriguing aspects of historical development that are not accounted for under previous diachronic explanations and present our novel account of the historical data.

3.2 *Synchronic phonology*

Neither Blust (2013) nor Burkhardt (2014) present any synchronic analysis of Berawan IVD. In this section, we demonstrate that the historical development of intervocalic devoicing gave rise to a gradient restriction against intervocalic voiced stops in the Berawan lexicon.

For the purpose of establishing the existence of an unnatural trend in the lexicon and its statistical significance, we analyzed all native vocabulary items from the vocabulary list in Burkhardt (2014). The list includes 425-466 vocabulary items, depending on the dialect. We counted occurrences of voiced and voiceless stops for all three places of articulation in all four dialects according to their position: initially and intervocalically. Clusters are disallowed in Berawan, which means that stops only surface initially, intervocalically, and word-finally. The word-final position is omitted from the count because stops are always voiceless word-finally due to the natural process of final devoicing. We included alveolar stops in the count because, due to intervocalic lenition, they also surface less frequently intervocalically. Counts are presented in Table 4.

The raw data analysis reveals that voiced stops are almost categorically prohibited from the intervocalic position where their occurrence ranges from 0 to maximally 4. In the initial position, on the other hand, voiced stops are allowed and surface with slightly lower, but similar frequencies as voiceless stops. Figure 1 summarizes the distribution.

To test the statistical significance of the restriction against intervocalic voiced stops, the data for each dialect was fit to a logistic regression model. The presence or absence of the voice feature was the dependent variable and Position (treatment-coded with the initial position as the reference) and Place of articulation (sum-coded with velar as the reference) were independent variables. Because of zeros in the count, the full model with all interactions was fit to a logistic regression model using bias-reduction (the model was fit using the `brglm()` function from `brglm` package; Kosmidis, 2013). The interaction of Place × Position was not significant for any of the four dialects (tested with LRT), which is why the data was refit

Dialect	Place	Voiceless #_	Voiceless V_V	Voiced #_	Voiced V_V	% Voiced #_	% Voiced V_V
Batu Belah	labial	52	10	40	2	43.5	16.7
	alveolar	56	32	22	4	28.2	11.1
	velar	43	54	13	0	23.2	0.0
Long Teru	labial	46	13	38	2	45.2	13.3
	alveolar	54	31	22	2	28.9	6.1
	velar	40	55	11	1	21.6	1.8
Long Jegan	labial	49	10	40	2	44.9	16.7
	alveolar	55	32	22	3	28.6	8.6
	velar	44	58	10	0	18.5	0.0
Long Terawan	labial	41	11	48	1	53.9	8.3
	alveolar	60	25	21	3	25.9	10.7
	velar	50	19	14	0	21.9	0.0

Table 4: Occurrences of stops in Berawan.

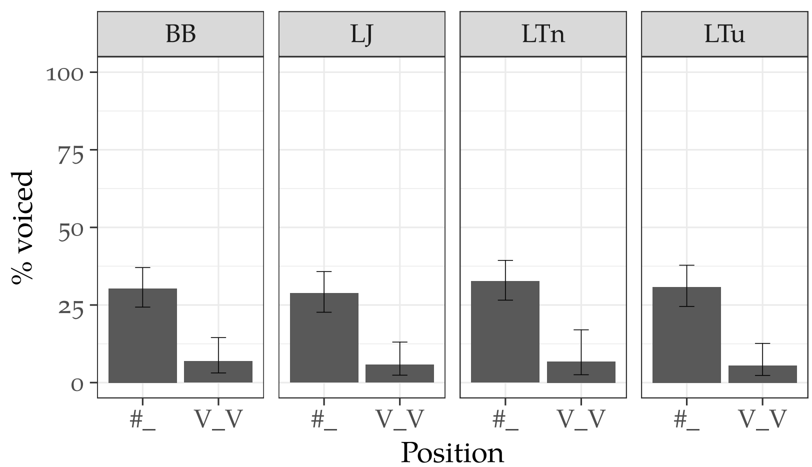

Figure 1: Percentage of voiced stops (across places of articulation) according to position—initial vs. intervocalic (from the logistic regression model in Table 5).

without this interaction to a logistic regression model without bias reduction (using `glm()`). The best-fitting model was chosen with LRT: for all four dialects, it includes the main effects of Position and Place. In all four languages, the voice feature in stops is significantly less frequent intervocalically compared to the initial position. Table 5 includes estimates for the main effect of Position for all four dialects.[6]

	Est.	z score	Pr(>|z|)
BB	-1.773	-3.906	0.0001
LTu	-2.028	-4.139	0.0000
LJ	-1.898	-3.860	0.0001
LTn	-1.893	-3.479	0.0005

Table 5: Estimates for the main effect Position (initial vs. intervocalic) from logistic regression models fit to Berawan data.

Based on these models, we can conclude that the Berawan dialects feature a significant trend in the lexicon that restricts voiced stops intervocalically. The statistically significant restriction against intervocalic stops in Berawan is unnatural according to the definition in (2); it operates against the universal phonetic tendency of intervocalic voicing.

The distribution of voicing in loanwords suggests that the gradient phonotactic restriction against intervocalic voiced stops was a part of productive alternations at least at some stage of development. Devoicing in loanwords operates sporadically. The collection of loanword vocabulary in Burkhardt (2014) includes cases in which devoicing applies regularly, e. g. Brunei Malay [pəsigupan] > Pre-Berawan *səgupan > BB [səkupen], as well as words in which no devoicing applies, e. g. Brunei Malay [sigup] > Pre-Berawan *sigup > BB [sigup].

This non-categorical devoicing in loanwords could also result from borrowing at different stages in the development, i. e. before or after the "intervocalic devoicing" sound change operated. (See Section 6 for arguments against intervocalic devoicing being a single sound change.) One piece of evidence against the latter scenario is the fact that Batu Belah [səkupen] 'pipe' and [sigup] 'tobacco' both go back to the same Brunei Malay root, yet one undergoes devoicing and the other does not. It is difficult to argue that two lexical items of the same root were borrowed at different times, although it is of course not impossible. In a list of 15 loanwords in Burkhardt (2014), there are six cases in which a voiced velar or labial stop surfaces in an intervocalic position in the donor language. In one case, devoicing occurs; in the remaining five cases, the stops remain voiced.

The dispreference for intervocalic voicing remains significant even if we add loanwords to the count. In all four dialects, voicing is significantly less frequent intervocalically compared to the initial position when loanwords are added to the count. Thus, we have demonstrated that the Berawan dialects exhibit a statistically significant trend in the lexicon—a dispreference for voiceless stops between vowels, which we interpret as a gradient phonotactic restriction according to Coetzee and Pater (2008). This gradient phonotactic restriction opposes a universal phonetic tendency, intervocalic voicing, and is thus unnatural by our definition. This means that Berawan exhibits a case of gradient unnatural phonotactics.

6 In all four dialects, the voice feature is also significantly more frequent in alveolars compared to the mean of all stops, but this is not of interest in this paper.

4 KIPUT

Kiput is a Malayo-Polynesian and, more specifically, North Sarawakan, Berawan-Lower Baram language of the Austronesian family, spoken by approximately 450 speakers in northern Sarawak in Borneo, Malaysia (Blust, 2002). It features several peculiar developments which have been extensively discussed in Blust (2002).[7] Section 4.1 focuses on the most unusual of these developments—the intervocalic devoicing, detailed in Blust (2002, 2005, 2013).

In Kiput, IVD does not result in a unnatural trend in the lexicon. This is discussed in Section 4.2. Nevertheless, the language provides insights into the historical development of unnatural phonotactics, shedding new light on the Berawan facts discussed in Section 3.1.

4.1 *Historical developments*

Blust (2002) establishes that the Pre-Kiput voiced velar stop *g, palatal affricate *ɟ͡ʝ, and labiodental fricative *v devoiced to Kiput [k], [c͡ç], and [f], respectively, in intervocalic position. Word-initial obstruents remain voiced. Word-final stops devoice by final devoicing; clusters are not allowed. Obstruents do not appear in other positions (Blust, 2002).

All three consonants that devoice (*g, *ɟ͡ʝ, *v) have transparent origins in Proto-North-Sarawakan (PNS; the direct predecessor of Pre-Kiput). Pre-Kiput *g goes back to a PNS voiced velar stop *g, whereas Pre-Kiput *ɟ͡ʝ and *v have various different sources in PNS. Pre-Kiput *ɟ͡ʝ continues PNS *ɟ͡ʝ or goes back to a PNS glide *j that is both phonemic and also automatic in hiatus sequences where the first vowel is high and front. By the same token, *v goes back to *w which can be either phonemic, or automatic in hiatus sequences where the first vowel is high and back (Blust, 2002).

Table 6 provides examples of intervocalic devoicing in Kiput. For the voiced velar stop series, the list is exhaustive: of 307 items on the vocabulary list with reconstructions in Blust (2002), four lexical items have intervocalic *g in Proto-North-Sarawakan (PNS). In three cases, devoicing occurs. The fourth case is an exception to this rule: PNS *tegeʀaŋ yields Kiput [təgəriə]. For the developments *ɟ͡ʝ > [c͡ç] / V _ V and *v > [f] / V _ V the table lists only a subset of all cases from the list. There are altogether 19 and 9 cases of devoicing of *ɟ͡ʝ and *v, respectively, in the same 307-word vocabulary list.

As mentioned above, the obstruents *g and *ɟ͡ʝ remain voiced word-initially. There are seven lexical items with Proto-North-Sarawakan initial *g in the 307-word Kiput vocabulary list. The voicsed velar stop *g remains voiced in all but one lexical item: Kiput [ketaan] for PNS

7 Recently, intervocalic devoicing has been reported as a synchronic alternation for Sula in Bloyd (2015a, 2017, 2020). It is clear from the data that the intervocalic devoicing there cannot be the result of a sound change: devoicing operates exclusively at morpheme boundaries, whereas elsewhere voiced stops remain voiced intervocalically (Bloyd, 2015b). The existence of intervocalic devoicing as a synchronic process there does not speak against our proposal. The alternations are nevertheless interesting from a synchronic perspective: it seems that there is indeed synchronic intervocalic devoicing in Sula. Because the data are sparse and the language is poorly described, we leave Sula out of our discussion. Further investigations into the prehistory of Sula and its synchronic alternations are a desideratum.

Sound change	Pre-Kiput	Kiput
*g > k / V _ V	*agem	akəm
	*pager	pakəl
	*tugal	tukin
*ɟ͡ʝ > c͡ç / V _ V	*puɟ͡ʝut	puc͡çut
	*taɟ͡ʝem	tac͡çəm
	*kaju > *kaɟ͡ʝu	kac͡çəw
	*lia > *lija > *liɟ͡ʝa	ləc͡çih
*v > f / V _ V	*ɟ͡ʝawaj > *ɟ͡ʝavaj	dafiəy
	*sawa > *sava	safəh
	*dua > *duwa > *duva	dufih

Table 6: Examples of intervocalic devoicing from Kiput (data from Blust, 2002, 2005).

*guta-an 'able to endure pain' (Blust, 2002, p. 411). The palatal affricate likewise remains voiced word-initially, but also loses its frication and develops to a voiced stop [d]. This occurs in three of four cases, e. g. *ɟ͡ʝawaj > [dafiəj]. In one word the affricate retains its frication: PNS *ɟ͡ʝauq yields Kiput [ɟ͡ʝəuʔ].[8] The voiced bilabial fricative *v does not appear word-initially. The data presented here (from Blust, 2002) thus confirms his claim that devoicing occurs exclusively intervocalically. Devoicing targets only the velar stop, palatal affricate, and labiodental fricative: voiced labial and alveolar stops remain voiced in all positions. The developments are summarized in Table 7.

Pre-Kiput	Kiput	
	# _	V _ V
*b	b	b
*d	d	d
*g	g	k
*ɟ͡ʝ, *j	d	c͡ç
*v, *w	/	f

Table 7: Summary of developments in Kiput (data from Blust, 2002, 2005).

Devoicing sometimes also operates in loanwords. Blust (2002) provides a list of 130 loanwords, mostly from Malay. In three cases, a borrowed voiced velar stop devoices, while it remains voiced in the remaining four, e. g. [sigup] → [sikup] vs. [bagi] → [bagiʔ]. The voiced palatal

8 Blust (2002) claims that in two cases initial *ɟ͡ʝ remains an affricate. However, Kiput [ɟ͡ʝəj] goes back to PNS *aɟ͡ʝaj, in which *ɟ͡ʝ appears intervocalically. [ɟ͡ʝəj] is therefore not a case of preservation of an initial affricate.

affricate devoices in three loanwords and remains voiced in six loanwords, e. g. [pi͡ɟɟit] → [pic͡çit] vs. [ra͡ɟɟin] → [ra͡ɟɟin].

To sum up, the above data suggest that unnatural intervocalic devoicing was a development from Pre-Kiput to Kiput. Blust (2005) goes a step further and claims that intervocalic devoicing had to occur as a single sound change because it targets only one feature and because there exists "no possibility of considering a concatenation of natural changes which cumulatively produced an unnatural result" (p. 243). In Section 6, we challenge this claim.

4.2 *Synchronic phonology*

In contemporary Kiput, there is no significant restriction against intervocalic voiced [g] any longer. We analyzed Blust's (2003) 932-word vocabulary list, which altogether contains 10 words with intervocalic [g] and 63 words with intervocalic [k]. While it is true that the voiced velar stop occurs much less often than its voiceless pair in the intervocalic position, this is likely to be a consequence of the fact that voiced velar stops in Kiput are in general less frequent that their voiceless pairs. The vocabulary list in Blust (2003) includes 121 instances of word-initial [k], but only 21 instances of word-initial [g]. The number of occurrences of [k] and [g] are represented in Table 8. Statistical significance is calculated using Fisher's Exact Test and Pearson's Chi-squared Test. The ratio of voiced to voiceless stops is almost identical across the environments. The restriction against voiced intervocalic stops is not statistically significant in Kiput, with *p*-value equaling 1.0.

	Voiceless		Voiced		% Voiced	
Place	# _	V _ V	# _	V _ V	# _	V _ V
velar	121	63	21	10	14.8	13.7

Table 8: Voiceless vs. voiced stops in Kiput word-initially and internally.

At a certain point in the past, diachronic IVD was likely to have created an unnatural phonotactic restriction against intervocalic voiced obstruents in favor of voiceless obstruents—a class of sounds otherwise dispreferred in that position. The fact that devoicing has happened in some loanwords provides evidence for this. However, the restriction was probably only active for a limited period of time, after which novel vocabulary was introduced in the language via borrowings and the alleged intervocalic devoicing ceased to operate. The fact that devoicing has only applied to loanwords sporadically, i. e. gradiently, may be evidence that the unnatural phonotactic restriction was gradient, as in Berawan.[9] (An alternative explanation is that loanwords were introduced to the language at different stages in its development.)

In sum, an unnatural development of intervocalic devoicing has been reported in Kiput; the data seemingly suggest that IVD indeed took palace in the language's pre-history. While the

9 See Beguš et al.'s (2022) study of Tarma Quechua for yet another case of gradient unnatural phonotactic restrictions. In Tarma Quechua, the voicing of stops is more common after voiceless obstruents than after nasal stops and intervocalically.

Kiput data do not provide direct evidence for the existence of unnatural gradient phonotactics, they offer important insights into the diachronic treatment of unnatural phenomena, as will be discussed below.

5 PREVIOUS ACCOUNTS

The most elaborate historical treatment of the alleged unnatural sound changes in Berawan and Kiput is given by Blust (2005). Blust's central claim is that unnatural sound changes *do* in fact exist. He specifically rejects the possibility that intervocalic devoicing could be anything but a single sound change: "intervocalic devoicing affected a single feature value. There is thus no possibility of considering a concatenation of natural changes which cumulatively produced an unnatural result" (p. 243). According to Blust, the Berawan data directly attest to the existence of unnatural sound changes precisely because the unnatural intervocalic devoicing had to operate as a single sound change.

The most common strategy for explaining unnatural sound changes is invoking Ohala's (1993) hypercorrection. Blust (2005) proposes that hypercorrection is the mechanism responsible for dissimilation which resulted in Berawan's intervocalic devoicing. Because the opposite process of intervocalic voicing is common, "the listener assumes wrongly that an assimilation has taken place and mentally 'undoes' it" (Blust, 2005, p. 243).

Blust (2005) acknowledges the problems that such an explanation brings. First, [±voice] is, according to Ohala (1993), a feature less commonly prone to dissimilation (Blust, 2005, p. 244). In addition, the dissimilation by hypercorrection hypothesis fails to explain why devoicing operates only on a subset of places of articulation (e. g. alveolars undergo lenition instead of voicing). Blust (2005) also discusses other proposals which invoke dissimilation as perceptual enhancement or claim intervocalic devoicing is phonetically motivated. All proposals face similar problems: they fail to account for asymmetries in voicing across different places of articulation. Due to the problems that all current proposals of intervocalic devoicing face, Blust (2005) leaves open the question of how exactly the unnatural sound change arose.[10]

Blust's (2005) argument against the possibility that multiple sound changes operated in the pre-history is also problematic. The fact that the sound change targets only one feature value is not in itself evidence that excludes the possibility of multiple sound changes operating in combination. In fact, in the next section, we present evidence in favor of the opposite view—that one single sound change could not have operated in the history of Berawan dialects.

10 Furthermore, none of the proposals discussed by Blust (2005) succeed at deriving the unnatural phonotactic restriction observed in other languages. E. g., in Tarma Quechua, voiced stops after voiceless obstruents are much more common than after nasals or intervocalically (Beguš et al., 2022). Hypercorrection is not well-suited for explaining these different rates of voicing; it is unclear why hypercorrection would operate more frequently postnasally or postconsonantally than intervocalically. One potential explanation for a lack of voicing postnasally within the hypercorrection approach could come from contacts with varieties of Quechua with postnasal voicing (Adelaar and Muysken, 2004). However, it is not clear that this contact occurred and how this hypercorrection might have operated. Additionally, this leaves the difference in voicing rates between postconsonantal and intervocalic positions unexplained.

6 A NEW ACCOUNT

In this section, we propose a new and unified treatment of historical developments leading to the unnatural intervocalic devoicing in the Berawan dialects (§3.1) and Kiput (§4.1). We argue that apparent cases of a single sound change operating in an unnatural direction are better explained as a combination of three natural sound changes (the so-called *blurring process*, Beguš, 2019). We demonstrate that our approach automatically derives several unusual aspects of the data, whereas Blust's (2005) unnatural sound change hypothesis fails to do so.

Our new explanation builds on a model for explaining unnatural processes presented in Beguš (2019). The model was developed on the basis of postnasal devoicing, an unnatural process that is reported as a sound change in thirteen languages (Beguš, 2019) and as a synchronic productive alternation in at least two (Coetzee and Pretorius, 2010; Hyman, 2001). Beguš (2019) argues that all thirteen cases show either direct or strong indirect evidence that a combination of three natural sound changes occurred, together giving rise to a synchronically unnatural result. Central to Beguš's (2019) model is a schema for explaining the sound changes needed for an unnatural process to arise, dubbed the *blurring process*.[11]

Just as with postnasal devoicing, it may appear on the surface that intervocalic devoicing operates as a single unnatural sound change. This, in fact, has been claimed for Berawan and Kiput (Blust, 2005). The fact that the unnatural phenomena in these languages are gradient provides an argument in favor of a single sound change hypothesis, as gradience is a prominent property of sound changes in progress. Using the *blurring process* model, however, we argue that the seemingly unnatural sound changes (in Berawan and Kiput) and the resulting phonotactic restrictions (in Berawan) arise from a combination of three natural sound changes. Finally, we point to the advantages that this explanation has over alternative single-sound change approaches. Section 6.1 outlines the blurring process, a model of historical development that reduced unnatural sound changes to a series of natural steps. Section 6.2 applies the model to the development of intervocalic devoicing in the Berawan dialects. Section 6.3 applies the model to the developments in Kiput.

6.1 *The blurring process*

First, let us assume that a single sound change is a change in one feature in a given environment and is always natural, i. e. it operates in the direction of universal phonetic tendencies. Furthermore, let us assume that A > B / X is one such natural sound change. Its opposite process, B > A / X, is then—by definition—unnatural, as it operates against a universal phonetic tendency. The question addressed in this section will be: how can an unnatural process/phonotactic restriction B → A / X arise?

To account for intervocalic devoicing, we adopt Beguš's (2019) *blurring process* model. Beguš (2019) proposes that unnatural phenomena result from a combination of a minimum of three

11 Beguš (2019) also formally proves that at least three sound changes are necessary for an unnatural alternation to arise. This result is termed the *minimal sound change requirement*.

sound changes. A single sound change by definition cannot produce an unnatural process. Two sound changes in combination can produce an unmotivated process, but not an unnatural one (Wang 1968 refers to unmotivated processes as *telescoping*.) For unnatural processes to arise, at least three sound changes need to operate. The three sound changes needed for an unnatural process B → A / X to arise are schematized in (4). (For a full argument motivating the requirement for at least three steps, see Beguš, 2019, 2020, 2022).

(4) BLURRING PROCESS (Beguš, 2019)

i. A set of segments enters complementary distribution.
ii. A sound change occurs that operates on the changed/unchanged subset of those segments.
iii. Another sound change occurs that blurs the original complementary distribution.

Two scenarios (i. e. two combinations of three sound changes) have been identified by Beguš (2019) to produce the unnatural B → A / X. They have been termed the *blurring cycle* (5a) and the *blurring chain* (5b), respectively.

(5) (Beguš, 2019)

a. BLURRING CYCLE
   i. B > C / ¬X
   ii. B > A
   iii. C > B

b. BLURRING CHAIN
   i. B > C / X
   ii. C > D
   iii. D > A

Postnasal devoicing in the thirteen reported cases results from a blurring cycle (Beguš, 2019). Voiced stops first undergo complementary distribution: they develop into voiced fricatives except postnasally. Then, the second sound change occurs—unconditioned devoicing of voiced stops. Because at this point stops surface only postnasally, the apparent result is postnasal devoicing. Finally, the last sound change occurs that blurs the initial complementary distribution: voiced fricatives occlude to stops.

This development is confirmed by several direct and indirect pieces of evidence. One of the languages in which postnasal devoicing operates as a sound change is Yaghnobi. Yaghnobi presents direct diachronic evidence in favor of the blurring cycle analysis as all stages of the development are historically attested (see Beguš, 2019; Xromov, 1972, 1987). The development is summarized in Table 9 (Beguš, 2019). The sound changes of the blurring cycle operating from Avestan and Sogdian (ancestors) to Yaghnobi that result in apparent postnasal devoicing are all directly attested in historical records (from Beguš, 2019).

In the rest of the paper, we argue that intervocalic devoicing in Berawan and Kiput is the result of the other type of blurring process described in Beguš (2019): the *blurring chain* (5b). In the blurring chain, a set of segments enters complementary distribution. Then, the changed segments undergo further change. Finally, the same set undergoes a third change. The result of the last change would give rise to the appearance of an unnatural sound change, were the chain collapsed into a single sound change. We argue that the application of the blurring chain model to Berawan explains several unusual aspects of the data set that the proposals discussed in Section 5 cannot account for.

Blurring Cycle		Example		
		Avestan	band	dasa
D > Z / [−nas]	d > ð / [−nas] _	Sogdian	βand	ðasa
D > T	d > t	Yaghnobi	vant	*ðasa
Z > D	ð > d	Yaghnobi	vant	das

Table 9: Development of coronals from Avestan to Yaghnobi (data from Novák, 2010).

6.2 *Blurring in Berawan*

Stage 1 in a blurring chain is the development of a complementary distribution (4i). The material presented in Section 3.1 provides several pieces of indirect evidence in support of the claim that stops in the three languages entered complementary distribution at some stage of development. The development of Pre-Berawan voiced stops is repeated in Table 10 below.

Pre-Berawan	Berawan	
	# _	V _ V
*b	b	k
*d	d	r
*g	g	k

Table 10: Summary of developments in Berawan.

An intriguing aspect of the Berawan development is that, while the labial and velar series undergo intervocalic devoicing (fortition or a decrease in sonority), the alveolar series of stops undergoes intervocalic lenition, i. e. an increase in sonority. Lenition of alveolars in intervocalic position suggests an earlier stage with complementary distribution (4i). Pre-Berawan *d develops to [r] intervocalically and remains a voiced stop [d] initially. It is likely that the increase in sonority intervocalically followed a gradual path via fricativization of [d]: *d > *ð > [r] (which is a common sound change, cf. Kümmel, 2007, pp. 60, 79). In other words, we reconstruct that voiced alveolar stops underwent intervocalic lenition to [r], likely through an intermediate stage with [ð], which means that at some point in the development [d] was in complementary distribution: the voiced stop surfaced as a fricative intervocalically. The asymmetry between labials and velars, on one hand, and the alveolars, on the other, is hard to explain under other accounts (see §5). Under the blurring chain approach, this asymmetry is actually expected.

Based on the development of the alveolars, we can reconstruct that such complementary distribution underlies the other two series of stops as well. Let us posit that Pre-Berawan first undergoes intervocalic lenition in all series of stops, not just alveolars.[12] Intervocalic fricativization of voiced stops is a common and phonetically motivated (Kaplan, 2010; Kirchner, 2001)—i. e. natural—sound change. As already mentioned, the alveolar series preserves this initial stage of complementary distribution in today's system: intervocalically, *d surfaces as [r] < *ð and does not undergo devoicing, while initially it is preserved as a voiced stop. Stage 1 of the development is illustrated in Table 11.

Pre-Berawan	Berawan	
	# _	V _ V
*b	b	β
*d	d	*ð > r
*g	g	g

Table 11: Stage 1 in the development of Berawan.

We propose that at the stage of complementary distribution in Pre-Berawan, another sound change occurred that targeted the changed subset of segments (4ii): unconditioned devoicing of voiced fricatives. Voicing in fricatives is highly dispreferred and articulatorily difficult to maintain—requirements for voicing and for frication are diametrically opposed which is the source of articulatory dispreference: "one condition requires oral pressure to be as low as possible, the other to be as high as possible" (Ohala, 2006, p. 688; see also Ohala, 1983, 1997; Smith, 1997). Unconditioned devoicing of fricatives is thus a natural, motivated, and common sound change. Because voiced fricatives at this stage surface only intervocalically, the result is an apparent intervocalic devoicing. Note also that because *ð further develops to [r], it

12 Blust (2023) challenges the proposal that the Pre-Berawan *b developed into [k] through the intermediate stage of the voiced bilabial fricative *β by pointing out that Proto-Berawan had a bilabial fricative which came from automatic transition glides after *u but did not develop into [k]. If *b had had the intermediate stage of *β, and *β later developed into [k], then—reasons Blust (2023)—we predict that, for example, 'Malayan sun bear' in BBB and LJB should have developed in ˣ[kukiŋ], as opposed to the attested [kuβiŋ]. The data used by Blust (2023) to motivate his counter-argument are given in Table A.

PNS	PB	LT	BB	LJ	
*bəRuaŋ	*bəguβiŋ	kəbiŋ	kuβiŋ	kuβiŋ	'Malayan sun bear'
*dua	*duβa	ləbih	duβeh	duβyəy	'two'
*bituʔən	*təkuβən	təkəbin	təkuβən	təkuβən	'star'
*kuay	*kuβe	kəbe	guβi	guβiæ	'Argus pheasant'
*puʔan	*puβan	pəban	puβan	poβan	'squirrel'

Table A: Reflexes of Proto-Berawan *β (from Blust, 2023 and Burkhardt, 2014, p. 166).

However, the fortified glide need not have been a bilabial fricative at the time of the first stage of the proposed blurring process yet. This is to say, we propose to reconstruct *bəguwiŋ, *duwa, *təkuwən, *kuwe, and *puwan for PB (as opposed to Blust's *bəguβiŋ, *duβa, *təkuβən, *kuβe, and *puβan). The diversity of the "fortified glide's" reflexes in daughter languages adds to the plausibility of this reconstruction.
At the same time, the change of *β > b in LT suggests that fricative occlusion works in these dialects, lending further support to the third stage of the blurring chain we posit.

escapes fricative devoicing and the original complementary distribution in the alveolar series is still preserved. Stage 2 is illustrated in Table 12.

Pre-Berawan	Berawan	
	# _	V _ V
*b	b	ɸ
*d	d	r
*g	g	x

Table 12: Stage 2 in the development of Berawan.

The blurring chain hypothesis has several advantages. The labial stop series in Berawan underwent not only devoicing, but also a change of place of articulation. The first advantage of the blurring chain approach is that this change of place of articulation is easier to motivate than under other approaches. The sound change [ɸ] > [x] or [β] > [g] (if it happened prior to devoicing) is more common than [p] > [k] or [b] > [g]. In fact, the only two cases of change of place of articulation from labial to velar in the survey of consonantal sound changes in Kümmel (2007) involve precisely fricatives; none are reported to involve stops. This distribution might be the result of greater perceptual similarity between [ɸ] vs. [x] or [β] vs. [g] than between [b] vs. [g], although extensive studies on the perceptual aspects of this change are lacking—many studies that test perceptual confusability involve differences between non-strident and strident fricatives (e. g. Alwan, Jiang, and Chen, 2011; Miller and Nicely, 1955). There exists some evidence of a perceptual motivation for the [ɸ] > [x] change: Redford and Diehl's (1999) data suggests that [f] vs. [θ] (another non-strident fricative) is perceptually more confusable compared to [p] vs. [t]. Regardless of how we motivate it, the change from labial to velar place of articulation is a more common sound change when the target is a fricative than when the target is a stop and an explanation that invokes the first is more desirable than an explanation that invokes the latter.

The change in place of articulation that operated in Pre-Berawan reveals another crucial piece of evidence in favor of the blurring chain approach: if we assume that intervocalic devoicing operated as a single sound change, we cannot chronologically order the change in place of articulation with respect to intervocalic devoicing. Let us consider the option that intervocalic devoicing operated as a single sound change. There are two logical chronological orders of intervocalic devoicing and the change of place of articulation: either one precedes the other or vice versa. The two possible orders are illustrated in Table 13.

If devoicing happened first, we would expect the original [p] from Pre-Berawan voiceless *p to change its place of articulation as well. This does not happen: Pre-Berawan *apuj yields [apoj] and not ×[akuj] in all four dialects. If the change in place of articulation happened first, we would expect it to operate in the word-initial position as well. This does not happen—Pre-Berawan *bibi yields [biki], not ×[giki]. The only possibility to chronologically order the two sound changes and derive the Berawan data with a single-sound-change approach is to limit the already unusual sound change—change of place of articulation in stops (b > g)—to an

Chronology 1		Chronology 2	
1. intervocalic devoicing	b > p	1. change of place	b > g
2. change of place	p > k	2. intervocalic devoicing	g > k

Table 13: Two possible relative chronologies under the assumption that IVD operates as one sound change.

even more unusual environment—the intervocalic position. This would be highly unexpected: stops are perceptually better cued internally than initially where formant transitions into closure are lacking. In the survey of consonantal sound changes in Kümmel (2007) there are no cases reported of a change of [b] to [g] in intervocalic position.

In fact, precisely the change of place of articulation that targets only intervocalic [b] while initial [b] remains unchanged strongly suggests that the two were at some point distinct sounds and that the sound changes of intervocalic devoicing and change of place of articulation operated on one of the two sounds in complementary distribution.

Finally, the last sound change of the blurring chain (4iii) that operated in Pre-Berawan was the occlusion of the velar voiceless fricative *x to [k]. Occlusion of fricatives is a natural and motivated sound change as well, although not as unidirectional as the other two in the blurring chain. Kümmel (2007) reports at least two cases of unconditioned sound change [x] > [k]. The sound change is also phonetically motivated: fricatives require more articulatory precision than stops (Ladefoged and Maddieson, 1996, p. 137). The occlusion of fricatives can be motivated as reducing this articulatory precision, i. e. the laxing of articulatory targets.

The sound change, *x > [k], blurs the original complementary distribution and the result is intervocalic devoicing, as it is attested in Berawan today. The blurring chain in Berawan that results in D > T / V _ V is summarized in (6).

(6) Blurring chain in Berawan
  i. D > Z / V _ V
  ii. Z > S
  iii. S > T

The reconstructed trajectory can be illustrated with a lexical item that includes both an initial and an intervocalic stop: Berawan [bikuj] 'pig' from Proto-Austronesian *babuj (7).

(7) Illustration of reconstructed trajectory
*babuj > *biβuj > *biɸuj > *bixuj > [bikuj]

In sum, there exist several advantages of the blurring chain explanation in Berawan. First, the lenition of the alveolar series of stops automatically follows from the new analysis: it reveals an earlier stage of complementary distribution. Likewise, the change in place of articulation becomes well-motivated and consequently, we solve the chronology problem summarized Table 13. Finally, all the sound changes we posited are natural and well-motivated.

6.3 *Blurring in Kiput*

Let us now turn to Kiput, where intervocalic devoicing—we argue—also resulted from a blurring chain. As in the Berawan dialects, Kiput's distributional facts clearly point to a stage with complementary distribution (stage 1 of the blurring chain). Sounds targeted by intervocalic devoicing in Kiput are summarized in Table 14.

Pre-Kiput	Kiput	
	# _	V _ V
*g	g	k
*ɟ͡ʝ, *j	d	c͡ç
*v, *w	/	f

Table 14: Devoiced sounds in Kiput (data from Blust, 2002, 2005).

Note that, while *ɟ͡ʝ devoices intervocalically, it also changes in the initial position: the affricate *ɟ͡ʝ loses its frication and develops into [d]. In other words, *ɟ͡ʝ in Kiput enters into complementary distribution. At stage 1, *ɟ͡ʝ surfaces as [d] initially and remains *ɟ͡ʝ intervocalically. Let us reconstruct that, like in Berawan, the velar stop enters a similar complementary distribution (4i)—it surfaces as a voiced fricative intervocalically and remains a stop initially. The voiced fricative [v] surfaces only intervocalically. Stage 1 is summarized in Table 15.

Pre-Kiput	Pre-Kiput	
	# _	V _ V
*g	g	ɣ
*ɟ͡ʝ, *j	d	ɟ͡ʝ
*v, *w	/	v

Table 15: Stage 1 in the development of Kiput.

At this point, we can posit that the second sound change of the blurring chain took place (4ii)—voiced fricatives and affricates devoiced unconditionally. Fricative and affricate devoicing is a well-motivated natural sound change (§6.2). The voiced palatal affricate devoices to [c͡ç], while the voiced labiodental fricative *v devoices to [f] and the voiced velar fricative *ɣ devoices to *x. Stage 2 is summarized in Table 16.

That fricatives indeed devoice in Kiput is confirmed precisely by the attested development *v > [f]. While *x further develops to [k] via occlusion (just like in Berawan, 4iii), [f] is still preserved as a fricative and directly shows that devoicing of fricatives operated in Pre-Kiput.

PRE-KIPUT	PRE-KIPUT # _	PRE-KIPUT V _ V
*g	g	x
*ɟ͡ʝ, *j	d	c͡ç
*v, *w	/	f

Table 16: Stage 2 in the development of Kiput.

Because affricates and fricatives only surface intervocalically, the blurring chain results in an apparent intervocalic devoicing.

In sum, we account for the development of the Kiput intervocalic devoicing by proposing a series of natural changes, which begins with a set of sounds entering a complementary distribution (word-initially, *ɟ͡ʝ develops to [d]), goes through fricative devoicing (including the attested *v > [f]), and ends up with a blurring of the original complementary distribution. Thus, the proposed sequence of sound changes is not only natural, but motivated by the data.

7 CONCLUSIONS

In conclusion, we presented two case studies of putative intervocalic devoicing in Berawan dialects and Kiput. The pre-Berawan sounds *g and *d between vowels both devoice (and velarize) to [k] in Berawan. Alveolar stops do not devoice, but instead undergo intervocalic lenition to [r]. The pre-Kiput *g, *ɟ͡ʝ, and *v devoice intervocalically to [k], [c͡ç], and [f].

To account for the development of intervocalic devoicing in both languages, we invoked Beguš's (2019) *blurring process* model that reduces unnatural processes to a series of independently motivated, phonetically grounded, and natural sound changes. In both languages, intervocalic devoicing instantiates the *blurring chain*. First, voiced stops fricativize intervocalically. Second, the newly arisen voiced fricatives devoice unconditionally. Third and last, the voiced fricatives unconditionally occlude. The three changes give the false appearance of unnatural intervocalic devoicing.

Thus, we demonstrate that seemingly unnatural phonological developments arise from a series of phonetically natural changes. Our findings bear on the role of phonetic naturalness in diachrony and synchrony. While it is clear that synchronic phonological grammar can feature unnatural yet productive processes and restrictions (Beguš et al., 2022; Coetzee and Pretorius, 2010; Dąbkowski, 2023; Hyman, 2001), our findings suggest that sound change always toes the line of phonetic naturalness; all unnatural developments follow from a series of natural changes obscured in the blurring process.

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