2025 ACTA UNIVERSITATIS CAROLINAE PAG. 177–194
PHILOLOGICA 3

TIMING THE DIFFERENCE: A STUDY OF GEMINATION IN DOGRI CONSONANTS

PRANAV BADYAL

ABSTRACT
This study examines the phonetic and phonological properties of singleton–geminate contrasts in Dogri within the context where the preceding vowel is short, i.e. in CVCV: word structures. Linear Mixed-Effects (LMER) statistical results reveal that geminates are temporally nearly twice as long as their singleton counterparts (~ 70 ms), followed by consistent shortening of the preceding vowel (~ 16 ms). The remaining segments, i.e., the word-initial consonant and the word-final vowel, remain indiscriminable across both word types, suggesting no anticipatory lengthening in geminate contexts for the former, and minor shortening (but statistically non-significant) among geminates for the latter.
Additional findings regarding voicing effects, phrase-level context, and overall word duration for both word types confirm cross-linguistic voicing trends: voiceless geminates are longer with added evidence of pre-consonantal vowel shortening relative to their voiced counterparts. Moreover, geminates show significantly longer durations in Fixed Phrase contexts than in Carrier Phrase. Lastly, the longer total word duration for geminates (~ 53 ms) suggests that gemination in Dogri extends beyond a local phonetic phenomenon, bearing a distinctive prosodic and phonological weight. These results posit the view that temporal elongation reflects their status as phonologically contrastive units, rather than being a by-product of durational redistribution of the segments.

Keywords: Dogri; geminates; singleton; Punjabi; gemination; duration; temporal; Jammu; Kashmir; Indo Aryan; length contrast; tenseness

1. Introduction

The western Pahari sub-branch of the modern Indo-Aryan language, Dogri (Glottocode: dogr1253, ISO 639-3: doi) is primarily spoken in the Jammu and Kashmir (J&K) region of India. Its origin can be traced through earlier historical phases, namely the Old Indo-Aryan (OIA) period (approximately 1500 B.C. to 600 B.C.) and the Middle Indo-Aryan (MIA) period (approximately 600 B.C. to 1000 A.D.) (Gupta & Chowdhary, 2024). It is spoken by approximately 0.21% of the Indian population (Language Census of India, 2011). As there are around 60,000 people who belong to diverse religions and tribes, who still practice transhumance around the J&K region (Warikoo, 2000), Dogri is

https://doi.org/10.14712/24646830.2025.27

sparingly spoken in the adjoining areas of Himachal Pradesh state and the northern areas of Punjab state. From a script-historical perspective, Dogri has undergone three phases of script development: Takri, New Dogra Script, and Devanagari. It is currently written in the Devanagari script, the same script used for Hindi, which itself evolved from the Sharada script around 1200 A.D. (see Gupta & Chowdhary, 2024, p. 8; Grierson, 1904, p. 67 for Takri script).

1.1 Purpose of the study

This paper aims to investigate the durational properties of singleton and geminate consonants in Dogri. To contextualise the findings, this study will draw cross-linguistic comparisons with related Indic languages and typologically diverse languages that exhibit a short–long consonant contrast.

However, given the limited body of linguistic research on Dogri in general, certain considerations are crucial in shedding more light on gemination patterns. For example, in a pilot study, Badyal (2023) focused solely on five voiceless stops [p, t̪, ʈ, tʃ, k], thus offering a narrow phonetic scope. Concerning Ghai (1991), it presents some limitations: some test words are either nonsense (made-up) or borrowed from Punjabi, possibly due to the author's native background Also, the analysis was performed manually, with spectral data presented as mingograms derived from tape-recorded acoustic signals.

By addressing the questions on Dogri geminates below, the study aims to confirm, refine, or potentially revise earlier findings, accounting for variation in the form of language change in Dogri, if any, particularly after 1991, by addressing the following questions:

a. C2 duration difference between singleton and geminate words.
b. Effect of place and voicing on C2 duration across both word types.
c. Effect of C2 on V1 and V2 duration in singleton vs. geminate contexts.
d. Are voiceless geminates longer than voiced ones?
e. Evidence of pre-consonantal vowel (V1) duration before voiced compared to voiceless for both word types.
f. Do geminate durations vary between fixed and carrier sentence contexts?
g. Is there C1 lengthening in geminate constructions?
h. Is the total word duration preserved between singleton and geminate words?

1.2 Geminates in Dogri

A geminate, usually defined as one single unit or a sequence of two identical consonants, is etymologically derived from a Latin word, 'geminus', meaning '*doubling*'. Most languages in the world have short/single consonants in their inventory, while some maintain a two-way length, i.e., a phonological quantity contrast in the form of a singleton-geminate that shows meaning contrast. This contrast offers a distinction between weak or lenis–strong or fortis–tense or lax consonant system in such languages.

As Blevins (2004, 2005) suggests, geminates may emerge through multiple evolutionary pathways including the assimilation of consonant clusters (CC) (see Ohala, 2007 for CC assimilation in Hindi), consonant + vowel/glide sequences, expressive or emphatic

lengthening, lengthening at word or morpheme boundaries, and occasionally through language contact (e.g., the emergence of voiced geminates in Japanese via loanwords), a comprehensive discussion of these origins falls beyond the scope of this paper. Thus, by limiting to Dogri and languages of Indic origin, in addition to native lexical geminates, the rise of geminates is closely linked with the historical assimilation of two clustered consonants (CC) among disyllable *tatsam* (of Sanskrit origin) words. It is triggered when one consonant occupies the coda of the preceding syllable and the other the onset of the following syllable. In case of word-final geminates, a geminate is formed when both the CC members are in the coda of simple monosyllable words (cf. Table 1 for the origin of Dogri geminates from CC).

Table 1 Geminates arising from CC assimilation in Dogri.

POA	Sanskrit	Hindi	Dogri	Meaning
palatal + retroflex	əʃʈ	ɑːʈʰ	əʈʰː	eight
labial + dental	səpt̪	sɑːt̪	sət̪ː	seven
alveolar + dental	həst̪	hɑːt̪ʰ	ət̪ʰː	hand
alveolar + labial	sərp(ə)	sə̃ːmp	səpː	snake
velar + palatal	sə.məkʃ	sə.məkʃ	sə.məkʰː	in front
velar + palatal	d̪ək.ʃɪn	d̪ək.ʃɪn	d̪əkkʰən	south
dental + alveolar	suːt̪r	suːt̪r	sʊt̪ːər	thread
dental + alveolar	muːt̪r	muːt̪r	mʊt̪ːər	urine
dental + alveolar	pɔːt̪r	pʊt̪r	pʊt̪ːər	son
dental + alveolar	kʃeːt̪r	kʃeːt̪r	kʰeːt̪ːər	an area

Dogri is a phonetic language (words are spelt as they are written, cf. Table 2 for [d̪] minimal pairs with short and long pregeminate vowel examples) that allows 19 consonants that can appear as geminates in Dogri in the word-medial and word-final position. Consonants including stops [p, pʰ, t̪, t̪ʰ, ʈ, ʈʰ, k, kʰ, d̪, ɖ, b, g], palatals [tʃ, tʃʰ, dʒ], sonorants [m, n, l], and a fricative [s] can appear as geminates in Dogri. All these geminate consonants also have a singleton form. Consonants [r, ɳ, ɽ, ʃ] only appear as singletons (Kaur & Dwivedi, 2018). An absolute word-final geminate in Dogri is a closed syllable that occurs after a short vowel only, and the geminate is followed by a non-phonemic vocalic release. Word-initial geminates are not allowed. Geminates do not occur flanked by another consonant on either side in a word in Dogri.

With respect to the preceding vowel in a CVCV template, geminates can occur in two types of environments across languages:

where a geminate appears immediately after a short-stressed vowel only, as in Swedish, Italian, Icelandic, Luganda, Hindi, Punjabi (Dulai & Koul, 1980) and,

where a geminate can appear both after a short as well as a long vowel, i.e., after central–peripheral, like in Dogri (see Table 2 below for examples), Lebanese Arabic (Khattab & Tamimi, 2014, p. 238) and Ta'zi dialect of Yemeni Arabic (Aldubai, 2015, p. 341).

Table 2 Orthographical representation of the Dogri singleton–geminate pair in IPA and Devanagari script.

Word Pair	IPA (Singleton)	IPA (Geminate)	Devanagari (Singleton)	Devanagari (Geminate)	Meaning (Singleton)	Meaning (Geminate)
1	səɖɑː	səɖɖɑː	सदा	सद्दा	always (verb, simple present)	call (verb, continuous)
2	dʒɑːɖiː	dʒɑːɖɖiː	जादी	जाद्दी	more	freedom

Languages that permit geminates in the context described in 2(b) are relatively rare. Many scholars have proposed that a short stressed centralised vowel preceding the word-medial consonant constitutes the most favourable phonetic environment for the realisation of geminates in Indic languages. Punjabi, the closest language to Dogri in the Indic group, adheres to this rule (see Bhatia, 1993; Gill & Gleason, 2013, p. 22; Hussain, 2015; Maddieson, 1985, p. 212). This preference may be attributed to the fact that a short vowel in a first stressed syllable creates an articulatory setting that facilitates sufficient constriction or frication, enabling the following consonant to be perceived and produced as durationally longer than its singleton counterpart. As a result, in Dogri, minimal word pairs containing a short vowel before the geminate consonant (CVCV) are more commonly attested than those featuring a long vowel in the same position (CV:CV) when contrasting singleton and geminate (S–G) forms. By word template, Dogri geminates are presented in Table 3.

Table 3 Dogri geminates occurring in different word templates among short and long pregeminate vowels.

Word Template	Word (IPA)	Preceding Vowel	Geminates in Word	Meaning
CVC:	sʊʈʈ	Short	ʈʈ	throw (imperative)
CVC:V:	ʧəkkɑː	Short	kk	wheel
CV:C:V:	ʧɑːkkiː	Long	kk	soap
CVC:V:C	kʰəɖɖəɽ	Short	ɖɖ	a kind of cloth
V:C:VC	ɑː.kkʰən	Long	kkʰ	ask (imperative)
CVCVC:V:	ʧə.kənn.ɑː	Short	nn	watchful
CVCV:C:V:	ʧə.lɑːkk.iː	Long	kk	cleverness

1.3 Temporal correlates of geminates

The study will focus on the temporal distribution of four segments, i.e., CVCV, in a S–G minimal pair across previously studied languages. It will also be examined how languages differ in the temporal distribution among segments. However, efforts will be made consistently to group findings that are consistent with Dogri and related Indic languages.

Within the CVCV minimal pair word structure, the absolute duration, comprising the closure and release phase of the intervocalic consonant (C2) stops, is the primary

acoustic correlate distinguishing singletons from geminates. This durational contrast is widely considered a universal phonetic phenomenon across languages. As Ladefoged & Maddieson (1996, p. 92) find, the absolute duration of C2 between singleton and geminates varies cross-linguistically. The evidence from previous research shows that across a range of typologically diverse languages, an S–G duration ratio of approximately 1:2 is commonly observed. Languages that adhere to this ratio include Dogri (Badyal, 2023), Cypriot Greek (Arvaniti, 1999), Yemeni Arabic (Aldubai, 2015) and Italian, specifically for stop consonants [p, t, k] (Esposito & Di Benedetto, 1999). The duration ratio higher than 1:2 however is attested in languages like Hindi, 1:2.5 (Shrotriya et al., 1995; Ohala, 2007, p. 354), Polish, 1:2.48 (Rojczyk, 2019), Pattani Malay (Abramson, 1986), while Berber languages demonstrate an overall consonant duration ratio of approximately 1:3 (Khattab & Tamimi, 2014, p. 232) (also see Table (ii) in Hamzah et al., 2016 for a detailed review on S–G duration ratio). However, in comparative studies, the consistency of these duration ratios remains a topic of debate due to various influencing factors, such as variability in speech rate (see Mitterer, 2018), positional effects (e.g., whether the target word is utterance-initial or phrase-medial), communicative context, and the semantic relation of the word within the carrier phrase, etc.

Regarding voicing of C2 (voiced vs. voiceless) among geminates, C2 voicing has a strong effect on its own duration, with voiceless consonants generally being longer than voiced ones. Importantly, the voicing of C2 also influences the duration of the preceding vowel (V1); voiceless geminates tend to be longer in duration than voiced ones. Such observations are made for languages like Hindi (Samudravijaya, 2003; Shrotriya et al., 1995, p. 133). In terms of articulatory phonetics, voiceless consonants require more precise control of airflow and greater tension in the articulators, which leads to a longer closure period. In contrast, voiced geminates require activation of vocal fold vibration and less airflow and tension, which lead to shorter durations.

Although geminates universally show compensatory lengthening of the C2, they also trigger temporal redistribution for the rest of the segments in a CVCV word template. The second important correlate in distinguishing geminates from singleton lies in the duration of the flanking vowels, namely, the preceding vowel (V1) and the following vowel (V2) relative to the intervocalic consonant (C2). With respect to V1 timing, Ridouane (2010) reports that in at least nine languages, the length of V1 plays a significant role in geminate contrasts. In the context of Indian languages, V1 shortening in geminate environments is a widely observed phenomenon, for example, in Hindi (Ohala, 2007, p. 355; Shrotriya et al., 1995, p. 134), Bengali (Lahiri & Hankamer, 1999), and Dogri (Badyal, 2023; Ghai, 1991). Previous research on V1 duration among Dogri geminates records a reduction of an average of 17 ms (Badyal, 2023). Interestingly, because geminates primarily emerged as a result of CC assimilation in Indic languages, similar reductions in the vowel preceding the cluster have also been reported, for example, in the case of Hindi (Shrotriya et al., 1996). With regard to V1 duration among voiced–voiceless geminates, it is also found that V1 duration tends to be longer among voiced stops than in comparison to voiceless stops (see Samudravijaya, 2003 for Hindi). This phenomenon is evident even in simple monosyllable words in non-geminating languages like English; consider word pairs, *bead–beat, seed–seat*, a range of 0.6 ~ 0.8 ms is attested (Cho, 2016; also see Kluender et al., 1988 for a review on production-oriented vowel length effect).

Concerning V2 duration, previous research shows that language-specific rules govern the role of the following vowel in differentiating singleton and geminates. While for certain Indic languages, notably Dogri (Badyal, 2023), and specifically Bengali, Ghosh (2015), in a three-way ANOVA examines the effects of gemination, place of articulation, and voicing on V2 duration and finds no statistically significant difference between singletons and geminates. Japanese, however, maintains a shorter duration for V2 when they follow geminates (Han, 1994, also cited in Hirata, 2007, p. 10). Similar V2 shortening effects have also been observed in Pakistani Punjabi (Hussain, 2015). However, findings from the Ta'zi dialect of Yemeni Arabic demonstrate a more consistent pattern, i.e., both V1 and V2 durations are reduced in geminate environments (Aldubai, 2015). These cross-linguistic differences suggest that V2 durational patterns in geminate contexts are language-specific, reflecting variation in phonetic realisation and prosodic structuring across languages.

Robust C1 lengthening effects have been reported for geminates and word-medial CC in languages such as Japanese (Han, 1994), Yemeni Arabic (Aldubai, 2015), and Italian (Turco & Braun, 2016). Aldubai's study on Yemeni Arabic, in particular, demonstrates C1 nasal [m] in geminate environment to be more than twice as long as in singleton contexts, ranging between 60 and 150 ms. The presence of C1 lengthening in geminates (and/or consonant clusters) contexts, whether consistent or variable across languages, is considered a natural and physiologically grounded phenomenon. It may be performed to facilitate the production of a longer C2 by providing articulatory strengthening or preparatory support during the utterance of a geminate word. However, in contrast, minor (non-significant and less consistent) lengthening effects have been observed in Pakistani Punjabi (Hussain, 2015) and in Hindi (Ohala, 2007, p. 357).

As discussed in the above section on the temporal distribution of segments in S–G word pairs, languages demonstrate distinct timing patterns, reflecting language-specific strategies that account for cross-linguistic variation between the two word types. Despite this variability, it is still possible to classify languages based on the durational characteristics of the pregeminate vowel because it emerges as the second most widely studied and is considered a reliable correlate in terms of reflecting significant statistical results across speakers and contexts, particularly in support of Indo-Aryan languages spoken in India. In this respect, languages can be grouped on the basis of three types:

a. Languages like Hindi (Ohala, 2007; Samudravijaya, 2003; Shrotriya et al., 1995), Bengali (Ghosh, 2015; Lahiri & Hankamer, 1988), Dogri (Badyal, 2023; Ghai, 1991, p. 38), Italian (see Esposito & Benedetto, 1999, p. 2059), Makasar (Tabain & Jukes, 2016, p. 103) and Tashlhiyt Berber (Ridouane, 2007) are reported to show the preceding vowel to be shorter among geminates in comparison to singleton in a CVCV minimal word pair.
b. Languages that lengthen the preceding vowel before a geminate, most notably in Japanese (Han, 1994; Hirata, 2007; Idemaru & Guion, 2008).
c. Languages that are reported to show no reductions in the duration of the preceding vowel between singletons and geminates are Polish (Rojczyk & Porzuczek, 2019), Maltese (Mitterer, 2018), Pakistani Punjabi (Hussain, 2015), Hungarian (Ham, 2001), Estonian (Engstrand & Krull, 1994) and Turkish (Lahiri & Hankamer, 1988).

2. Methods

2.1 Participants

Ten participants (6 males and 4 females) with no reported history of speech or language disorders and between the ages of 25 and 69 were recruited in Jammu, J&K, India. All participants were at least bachelor's level or higher educated and had been residing in the Jammu region for a minimum of ten years, and none had resided outside of India. In terms of competence in other languages, all participants reported fluent articulation in Hindi and English (English language onset age: no later than 8 years). Each participant reported having learned Dogri prior to English and used Dogri for at least 70% of their daily communication.[1]

2.2 Materials and experimental design

The material consisted of 13 pairs of disyllabic test words following a CVCV word template, each forming a true minimal pair contrasting singleton and geminate consonants. The word-medial consonants were selected based on four places of articulation: (i) bilabial, (ii) dental, (iii) retroflex, and (iv) velar, further categorised according to the manner of articulation (stop, nasal, liquid) and also by phonological voicing (voiced–voiceless). Six voiceless C2 were included, whereas voiced consonants were seven. The word-final vowel in all test word pairs was always long, to control for post-consonantal vowel effects.

Each pair in both environments was embedded in two types of reading stimuli: (i) a fixed carrier phrase, and (ii) meaningful, semantically coherent carrier sentences, and the target word appeared in phrase/sentence-medial position. For the Fixed Phrase condition, the structure [ʊs ____ sʊneːɑː], *he/she* _____ *listen* (simple past) was used, with the blank space representing either a singleton or geminate word. In the meaningful sentence condition, the test words were contextually integrated into natural sentences to preserve the spontaneity and naturalness of speech. This setup was designed to examine whether semantic relatedness influences the articulation of geminates. Filter tokens, i.e. distractor items not analysed in the present study, were also included to avoid the emergence of identifiable patterns. Table 4 presents a full inventory of phonemes included in the stimuli (see Appendix for the reading material).

Table 4 The phonetic distribution of segments in the CVCV word form included in the stimuli.

	Phoneme
No. of word pairs	13
C1	t̪ k b g f tʃ s m r
V1	ə ʊ
C2	p t̪ ʈ t̪^{h} k ɖ g l m n
V2	eː ɑː iː

[1] Before participation, all individuals completed an informed consent form in accordance with ethical research procedures.

2.3 Procedure

The recording sessions took place in a sound-attenuated recording studio. All materials were presented in Devanagari script. Before the experiment, the participants were briefly familiarised with the sentence lists, followed by on-screen instructions. Participants were instructed to read at a normal, relaxed speaking rate to minimise hyperarticulation. Participants were allowed to repeat a sentence if they stumbled or mispronounced a word, ensuring fluency and consistency of data.

Each participant was individually recorded reading each test word three times under each stimulus condition, resulting in randomised lists of items. On average, the total duration of the experiment for each participant lasted 10–12 minutes.

All speech was recorded in stereo mode, at 44.1 kHz, and encoded in 16-bit, uncompressed WAV format using a Zoom H1N recorder with cardioid dynamic features. The audio signal was recorded on the hard disk of a desktop computer. Stereo recordings were converted to mono by averaging the two channels, using the default mono conversion feature of the Praat speech software package, version 6.3.16 (Boersma, 2023).

2.4 Measurement and acoustic analysis

Acoustically recorded speech data were annotated for each phoneme of interest using Praat software (see Figures 1 and 2 for the segmentation criteria followed).

The word of interest had the following phases:

a. duration of the word-initial consonant (C1),
b. duration of the preceding vowel (V1),
c. absolute (closure and release) duration of the word-medial consonant (C2),
d. duration of the word-final vowel (V2), and
e. total duration of the test word (C1+V1+C2+V2 durations)

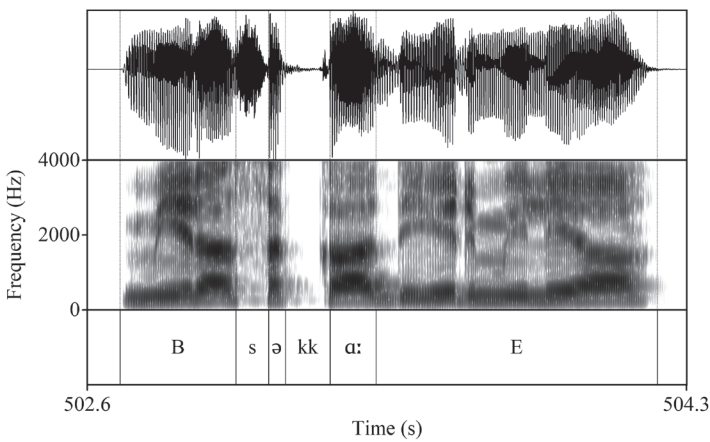

Figure 1 Segmentation of voiceless geminate test word [səkkɑː] in meaningful carrier phrase.

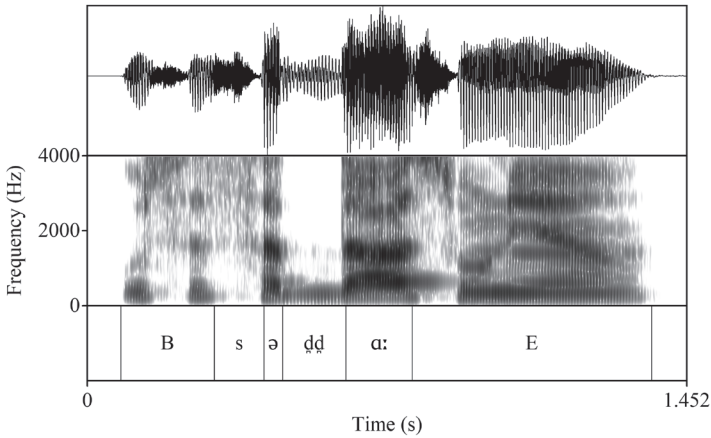

Figure 2 Segmentation of voiced geminate test word [səd̪d̪ɑː] in fixed phrase.

Out of a total of 1560 tokens generated during the experiment (26 words from 13 minimal pairs × 6 repetitions × 10 participants), 770 tokens occurred within the Fixed Phrase environment and 790 within the Meaningful Carrier Phrase.

3. Analyses and results

A linear mixed-effects analysis (LMER) was performed using R and the *lme4* package to examine the relationship between C1–V1–C2–V2 and Consonant Type (singleton/geminate) (Bates et al., 2015). The model included the Consonant Type and Place of Articulation as fixed effects, along with their interaction. As random effects, subject-level intercepts and by-subject random slopes for consonant type were incorporated. Visual inspection of the residual plots revealed no substantial violations of homoscedasticity or normality. Using the *lmerTest* package (Kuznetsova et al., 2017), *p* values were derived via the Satterthwaite approximation. Post hoc analyses (Tukey test) were obtained from the *emmeans* package to draw contrasts between variables (Lenth, 2025).

For C2, the model revealed that there was a significant effect of Consonant Type (S/G) on C2 duration, $F(1, 8.99) = 180.84$, $p < .001$, indicating that geminates were significantly longer than singleton with an estimated mean difference of 72.4 ms. There was also a significant main effect of Place, $F(3, 1542.84) = 27.6$, $p < .001$, and a significant interaction between Consonant Type and Place, $F(3, 1548) = 6.2$, $p < .001$, indicating singleton–geminate contrast varied at four places of articulation.

Concerning V1, a strong effect was found when the word was a singleton or a geminate, $F(1, 9.01) = 23.67$, $p < .001$, maintaining an average duration difference of 16 ms. There was also reported a significant effect of Place, meaning the duration differed between the two word types, $F(3, 1542.20) = 3.89$, $p = .008$. As far as interaction between Consonant Type and Place is concerned, it was found significant, $F(3, 1539.15) = 2.99$, $p = .02$, confirming pre-consonantal vowel shortening among geminates.

V2 had a significant effect of Consonant Type, $F(1, 8.9) = 16.62$, $p < .002$ and Place, $F(3, 1544.89) = 12.24$, $p < .001$, but there was no interaction effect, $F(3, 1541.11) = 1.02$, $p = .3$. The results from pairwise contrasts revealed that despite minute overall shortening of the vowel among geminates, V2 statistically remained similar across all places for singleton and geminates, except for Dentals (7.4 ms), with vowel preceding singleton being longer.

Lastly, for C1, the main effect of Consonant Type was not significant, $F(1, 943.16) = 0.40$, $p = .5$, while Place showed a strong effect, $F(3, 940.11) = 231.28$, $p < .001$. Importantly, there was a significant Word Type × Place interaction, $F(3, 937.10) = 3.70$, $p = .01$, suggesting that the C1 duration contrast between singletons and geminates varied by Place. However, post-hoc comparisons revealed no significant durational differences between singleton and geminate C1 durations at any articulation place. The independent mean duration for four segments grouped by Place of C2 articulation in singleton-geminate word pairs is presented in Table 5.

Table 5 Mean durations for C1–V1–C2–V2 in singleton–geminate CVCV words across four places of articulation. The values in the parentheses represent the standard deviation.

Pair	Place	Voicing	C1 (S)	V1 (S)	C2 (S)	V2 (S)	C1 (G)	V1 (G)	C2 (G)	V2 (G)	Word (S)	Word (G)
p pp	Bilabial	VL	129 (36)	66 (16)	89 (15)	128 (32)	130 (35)	54 (15)	159 (29)	123 (30)	412	465
t̪ t̪t̪	Dental	VL	128 (32)	60 (15)	91 (18)	130 (30)	131 (44)	46 (13)	170 (31)	129 (22)	409	475
ʈ ʈʈ	Retro	VL	123 (27)	69 (17)	81 (19)	127 (29)	132 (34)	54 (14)	149 (18)	118 (28)	400	452
t̪ʰ t̪t̪ʰ	Dental	VL	118 (34)	75 (17)	112 (23)	129 (30)	120 (41)	59 (15)	188 (28)	123 (32)	434	488
k kk	Velar	VL	122 (25)	63 (13)	84 (18)	131 (34)	125 (27)	48 (13)	163 (26)	126 (24)	399	461
d̪ d̪d̪	Dental	V	115 (28)	77 (18)	58 (12)	142 (27)	120 (29)	61 (14)	133 (23)	133 (27)	391	447
g gg	Velar	V	100 (22)	81 (19)	57 (11)	132 (27)	116 (36)	66 (15)	121 (23)	130 (23)	369	433
l ll	Dental	V	126 (39)	73 (20)	51 (10)	136 (30)	133 (44)	55 (17)	125 (24)	125 (26)	385	438
m mm	Bilabial	V	55 (30)	84 (22)	84 (13)	121 (26)	50 (28)	66 (14)	136 (27)	114 (32)	344	365
n nn	Dental	V	130 (35)	78 (19)	48 (20)	127 (37)	126 (35)	54 (15)	133 (30)	121 (26)	382	434

Thus, C2 and V1 provide robust temporal correlates in differentiating Dogri singleton and geminates. As anticipated, at four places of articulation, all 13 phonemes show a 2:1 G–S ratio, singleton maintaining an average of 72 ms shorter duration. The C2 timing

contrast between the two word types by Place type is 64 ms for Bilabials, 78 ms for Dentals, 66 ms for Retroflex, and 72 ms for Velar consonants. Hindi, in contrast, an Indic language, is attested to maintain a larger value of approximately 2.5 times (Shrotriya et al., 1995).

In parallel, V1 is consistently shorter in duration for geminates at all four places of C2 articulation, averaging about 16 ms. This pattern is consistent with an earlier study conducted on Dogri voiceless geminates that showed an average duration difference of 17 ms (Badyal, 2023). The small variation (~ 1 ms) is likely due to natural speech variability and the inclusion of voiced consonants. Similar patterns of pre-consonantal vowel reduction have also been observed in Bengali (Ghosh, 2015), supporting the cross-linguistic preceding vowel shortening generalisation. At four places, namely, Bilabial, Dental, Retroflex, and Velar geminates show an average shortening of 13.5, 18, 15, and 14 ms, respectively, in Dogri. The correlation between V1 and C2 durations by Place of Articulation is presented in Figure 3.

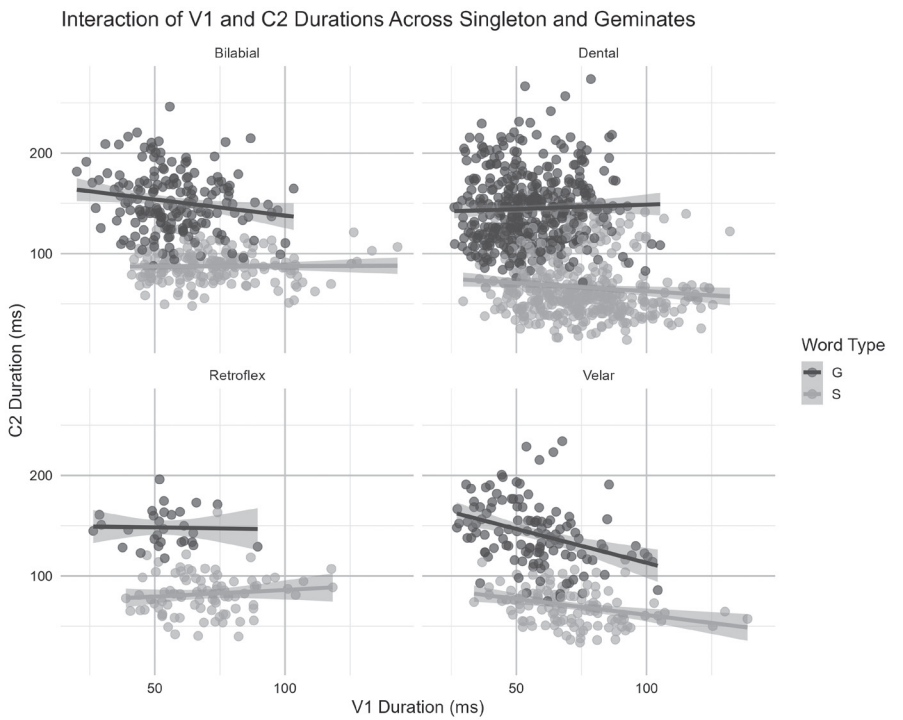

Figure 3 Scatterplot of V1 and C2 durations by word type and consonant place.

Regarding C1, in total, six consonants comprising of four voiced consonants, stops [b, g] and sonorants [m, r], and two voiceless fricatives [f], [s] were included for measuring the temporal difference. These consonants exhibit clearly identifiable onset and offset boundaries due to their manner (voicing for stops) and frication noise (for fricatives). Voiceless stops, however, were not included due to the difficulty in accurately determining

their onset timing. Average durations for each phoneme show that overall, C1 durations show minute but non-significant lengthening effects among geminates for [b, g, f, s], as C1, [b] maintains the longest closure duration due to its feature as voiced bilabial plosive (closure and release burst), while [s] (continuous voiceless frication) the least (cf. Figure 4). However, it is interesting that besides minute lengthening of the consonant among geminates, the C1 in word pairs [rəmiː – rəmmiː] and [məniː – mənniː] is not lengthened, but gets shortened. One potential rationale is that phonetically, sonorants, [m] and [r], generally exhibit shorter durations, with less stable articulatory gestures. Phonologically, in particular, [r] lacks a geminate counterpart in Dogri and is realised as a tap, a brief and rapid articulation. Additionally, the [rVm] and [mVn] sequences are voiced and homorganic/near-homorganic, creating a sonorant-to-nasal environment which is conducive to gestural overlap and articulatory blending. This overlap likely reflects a form of speech economy, whereby the C1 gesture is absorbed into the following nasal. Historically, Dogri has shown a tendency to assimilate certain homorganic CC, resulting in the formation of a geminate, e.g., OIA, [sərpɑ] to MIA, [səpp(ə)] (*serpent*) (cf. Table 1). Lastly, since the contrastive weight in such a word pair falls on the geminate [nn], which serves as the primary cue for lexical distinction, the C1 may be reduced in duration because of this phonological emphasis.

V2, though, consistently shows reductions among geminates, but the difference in contrast with the singleton is negligible (6 ms shorter for geminates on average). The minor shortening is attributed to the fact that geminates are longer by nature and consume more of the word-level time window. In order to maintain an overall prosodic timing in time-sensitive languages, the vowel is compressed to a certain degree. For all four phonemes, i.e. C1, V1, C2, and V2, mean durations in the form of violin plots by place of articulation for both word types are presented in Figure 4 a, b, c, and d, respectively.

Separate LMER tests were run to assess the effects of total word duration and voicing effects on C2 and V1 durations with random intercepts and slopes for Word Type by Speaker.

The test run to assess the effects of Word Type and Place on total word duration revealed that there were significant effects of Word Type, $F(1, 8.99) = 56$, $p < .001$ and Place, $F(3, 1542.82) = 7.26$, $p < .001$, on the total word duration. There was also a strong interaction effect, $F(3, 1539.51) = 3.08$, $p = .02$, indicating the duration to be longer for geminates than singleton at all articulation places with an average of 54 ms.

The observations about the total word durational difference between S–G pairs show that geminate words are longer despite contractions in the preceding vowel, as presented in Figure 5a. On average, geminates exceed singleton by 53 ms, with place-specific differences: Bilabials (41 ms), Dentals (55 ms), Retroflexes (53 ms), and Velars (66 ms). Longer geminate words imply that length distinction is part of the phonological grammar in Dogri in the environment when V1 is short, is actively maintained and not neutralised or redistributed in the mental lexicon of speakers, thus preserving the durational prominence of the lengthened consonant. It shows that geminates are not a variant of a single consonant but carry an additional prosodic weight to the word.

Since the stimuli included target words embedded in both Fixed and Meaningful Carrier Phrases, it was observed that both word types exhibited longer closure durations in the Fixed Phrase condition. However, with minor lengthening among singleton in the

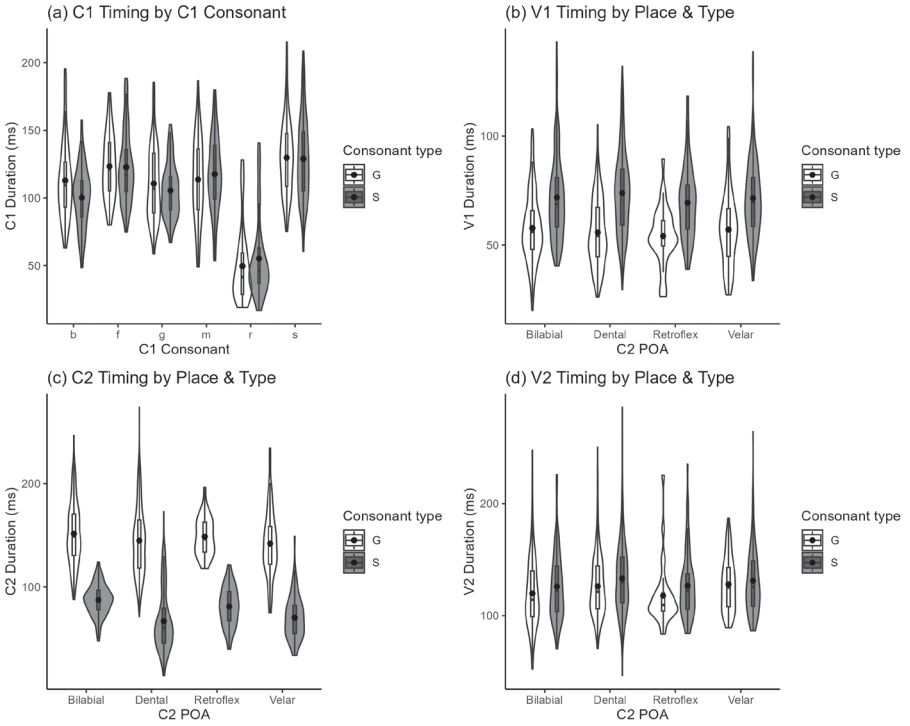

Figure 4 C1–V1–C2–V2 mean duration by articulatory place in singleton–geminate consonants.

Fixed Phrase context as opposed to when in the Carrier Phrase, the contrast is statistically insignificant (Bilabials: 2.45 ms, Dentals: 3.1 ms, Velars: 13.94 ms). Geminates, contrastively, show much longer duration; words tend to be significantly longer in Fixed Phrase (cf. Figure 5 b). This pattern was maintained across all places of articulation for C2 (Bilabials: 13 ms, Dentals: 16.4 ms) except for Velars: 9.1 ms. A plausible interpretation is that as opposed to singleton, geminates within fixed phrases are usually produced with greater articulatory care, likely due to the more controlled and isolated nature of the context, involving only two flanking words, i.e. ʊs ___ sʊneːjɑː, compared to the faster, natural, and more fluent speech characteristic of semantically coherent carrier phrases. The natural speech may overlap segments or facilitate coarticulation, leading to an overall shorter duration of both word types in carrier phrases. Thus, geminate consonants appear more sensitive to speech rate, emphasis, or prosodic phrasing than singletons.

The model was run to assess the effects of Voicing (voiced vs. voiceless), Word Type, and Place (Bilabial, Dental, Velar) on C2 and V1 durations. For C2, the analysis output significant main effects of Voicing, $F(1, 1421.28) = 808.4$, $p < .001$, Place, $F(2, 1421.31) = 28.95$, $p < .001$, and Word Type, $F(1, 9.23) = 169.13$, $p < .001$. In addition, significant interactions were observed: Voicing × Place, $F(2, 1421.41) = 89.41$, $p < .001$, Voicing × Word Type, $F(1, 1421.30) = 17.71$, $p < .001$, Place × Word Type, $F(2, 1421.30) = 23.35$, $p < .001$, Voicing × Place × Word Type, $F(2, 1421.40) = 9.30$, $p < .001$. These results indi-

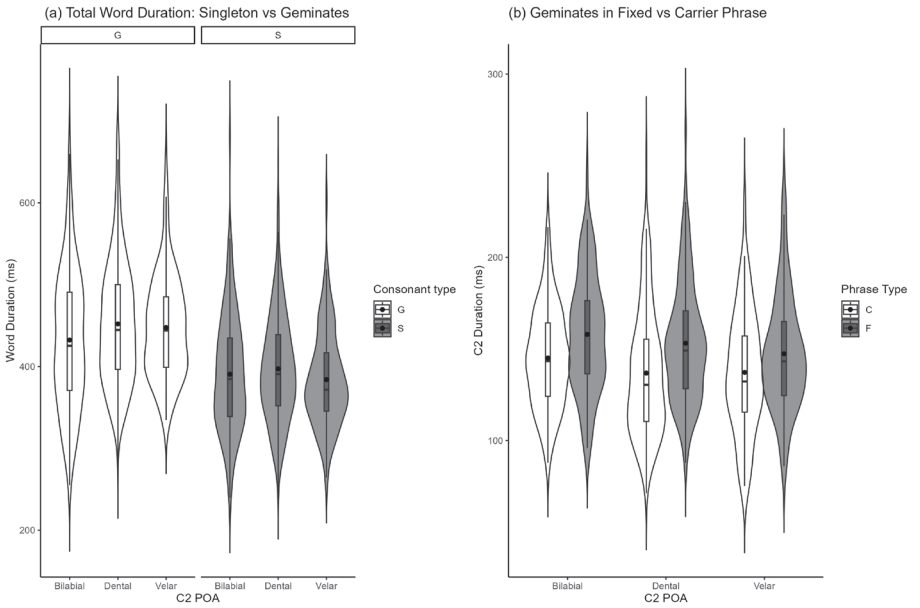

Figure 5 a) Total word duration (C1+V1+C2+V2) among Dogri singleton and geminates; b) Dogri geminates among fixed vs. carrier phrases.

cate that C2 duration is significantly influenced not only by voicing, place of articulation, and word type individually, but also by their interactions, suggesting that the voicing effect on C2 duration differs by both place and singleton/geminate status.

Concerning the effect of voicing on length-contrasting word pairs, it is revealed that C2 among voiceless singletons and geminates is consistently longer than the voiced counterparts in Dogri. While voiceless word-medial consonants among geminates are reported to be 36.8 ms longer than their voiced counterparts, whereas C2 among voiceless singleton maintained an average of 48 ms and 28 ms for Dentals and Velars, respectively, with minor lengthening of 5.8 ms among Bilabial singleton pair (statistically non-significant, $p = .66$). Among Bilabials, the minimal pair with C2 [p]–[m], despite their voicing contrast, shows minute lengthening effects for voiceless singleton may be attributed to the intrinsic durational properties of nasals like [m], which are generally shorter compared to voiceless stops like [p] due to the manner difference. In other words, a stop, in this case, is a burst type followed by aspiration, whereas a nasal is accompanied by continuous voicing, making the pair not ideal to show robust contrast on C2 duration. This theory is validated by the observation that, among voiced–voiceless geminates, bilabials show the least duration separation (23 ms) as opposed to Dentals (46.2 ms) and Velars (41.2 ms). Thus, both phonemes are qualitatively different, regardless of the word type (S/G).

Similarly, for effects of voicing on V1 duration, the analysis revealed significant main effects of Voicing, $F(1, 1421.10) = 291.02$, $p < .001$, Place, $F(2, 1421.11) = 9.87$, $p < .001$, and Word Type, $F(1, 9.31) = 20.88$, $p = .001$. A significant interaction was also found between Voicing and Place, $F(2, 1421.12) = 19.88$, $p < .001$. However, the interaction

between Voicing and Word Type was not significant, $F(1, 1421.12) = 2.84$, $p = .09$, while the Place × Word Type interaction, $F(2, 1421.09) = 1.85$, $p = .15$, and the three-way interaction (Voicing × Place × Word Type), $F(2, 1421.11) = 1.36$, $p = .2$, were also found to be non-significant.

The impact of voicing on the preceding vowel further attests that V1 is shorter before voiceless singleton and geminates, a pattern reflecting cross-linguistic tendencies of pre-consonantal vowel shortening before voiceless obstruents (see Shrotriya, 1995; Maddieson & Gandour, 1975 for Hindi; Ghosh, 2015 for Bengali). On average, V1 among singleton voiceless words are 14.5 ms shorter than the voiced counterpart, with a place-specific duration difference of 16 ms for Bilabials, 10 ms for Dentals, and 17.6 ms for Velars. V1 among voiceless geminates, on the other hand, are found to be 11.8 ms shorter on average. This finding attests that the vowel preceding the consonant tends to be shorter. The influence of C2 voicing on Consonantal (C2) and Vowel Durations (V1) is presented in Figure 6. Retroflex consonants were excluded due to the absence of a corresponding voiced retroflex word pair in the stimuli.

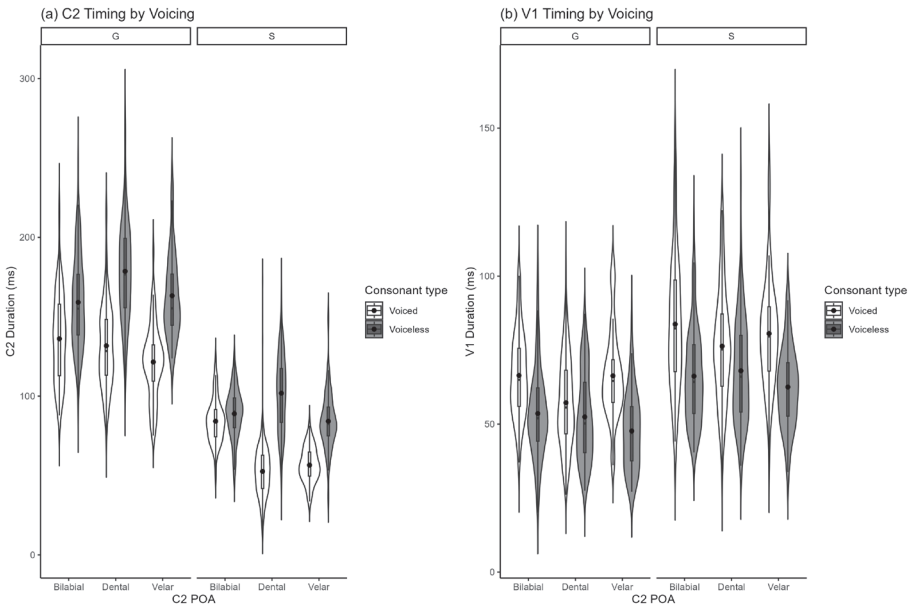

Figure 6 Effects of C2 voicing on consonantal (C2) and vowel (V1) durations.

4. Conclusion

In conclusion, the contrast between Dogri singletons and geminates is phonetically marked by geminates being almost twice as long as singletons, accompanied by pre-consonant vowel shortening. The duration of the word-initial consonant and the word-final vowel remains stable across both word types, indicating no anticipatory lengthening for

geminates for the former. The voicing contrast between the two word types aligns with cross-linguistic patterns; voiceless geminates exhibiting longer durations and the preceding vowels showing shortening compared to their voiced counterparts. Within Fixed vs Carrier Phrase contexts, geminates show longer duration for the former. The longer total word duration for geminates evidences that gemination is not merely a local (segmental/phonetic) phenomenon but rather has distinctive phonological weight. In other words, despite the non-compensatory nature of the initial consonant, shortening of the preceding vowel and of the final vowel among geminates, geminates are realised with an overall temporal increase, rather than "through" redistribution, reflecting their phonological status within the language.

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APPENDIX

Test word pairs with a short pregeminate vowel (CV̲CV:)

	Phoneme	Place	Manner	Voicing	Singleton	Geminate
1	p	Bilabial	Stop	Voiceless	təpɑ:	təppɑ:
2	p	Bilabial	Stop	Voiceless	tʃəpe:	tʃəppe:
3	t̪	Dental	Stop	Voiceless	kut̪e:	kut̪t̪e:
4	ʈ	Retroflex	Stop	Voiceless	pʰəʈi:	pʰəʈʈi:
5	t̪ʰ	Dental	Stop	Voiceless	kət̪ʰɑ:	kət̪ʰt̪ʰɑ:
6	k	Velar	Stop	Voiceless	səkɑ:	səkkɑ:
7	d̪	Dental	Stop	Voiced	səd̪ɑ:	səd̪d̪ɑ:
8	d̪	Dental	Stop	Voiced	gəd̪ɑ:	gəd̪d̪ɑ:
9	g	Velar	Stop	Voiced	bəgɑ:	bəggɑ:
10	l	Dental	Lateral	Voiced	kəlɑ:	kəllɑ:
11	m	Bilabial	Nasal	Voiced	rəmi:	rəmmi:
12	n	Dental	Nasal	Voiced	sʊne:	sʊnne:
13	n	Dental	Nasal	Voiced	məni:	mənni:

RESUMÉ

Tato práce zkoumá fonetické a fonologické vlastnosti kontrastů mezi jednoduchými a zdvojenými souhláskami (gemináty) v jazyce dogri v pozici, kde předchozí samohláska je krátká, tj. ve slovní struktuře CVCV:. Statistické výsledky ukazují, že zdvojené hlásky jsou časově téměř dvakrát delší než jejich jednoduché protějšky (~ 70 ms), přičemž dochází ke konzistentnímu zkrácení předcházející samohlásky (~ 16 ms). Zbývající segmenty, tj. souhláska na začátku slova a samohláska na konci slova, zůstávají u obou typů slov bez významných změn.

Další zjištění týkající se efektů znělosti, kontextu na úrovni fráze a celkového trvání slov u obou typů potvrzují obecné trendy znělosti: neznělé gemináty jsou delší s přidaným důkazem zkrácení samohlásky před souhláskou ve srovnání s jejich znělými protějšky. Navíc gemináty vykazují významně delší trvání v kontextech pevných frází než v kontextech nosných frází. A konečně, delší celkové trvání slov u geminát (~ 53 ms) naznačuje, že geminace v dogri přesahuje lokální fonetický jev a má výrazný prozodický a fonologický význam. Tyto výsledky podporují názor, že časové prodloužení odráží jejich status jako fonologicky kontrastivních jednotek, spíše než že by bylo vedlejším produktem přeskupení trvání segmentů.

Pranav Badyal
Institute of Phonetics
Faculty of Arts, Charles University
Prague, Czech Republic
pranav.badyal@ff.cuni.cz