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Phonological Typology of Velar Nasals

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Abstract: This study covers four typological topics concerning the velar nasal, based on extensive language data (1,411 languages from 7 macro-areas): its types, inventories, distinctions from other primary nasals, and distribution within syllables. The findings indicate that the velar nasal is more marked and less prominent than other major nasals such as the bilabial and dental/alveolar nasals. Its type diversity, language frequency, and percentage in nasal inventories are low, and its hierarchy in implicational relationships is more marked than those of other nasals. In many languages, the plain voiced velar nasal, /ŋ/, is not restricted in terms of occurring either at onset or in the coda, contrary to a widespread misunderstanding.

Key words: velar nasal, nasal, velar, phonological typology, phonotactics

1. Introduction

Nasals are a class of consonants that are articulated through three stages (closure, hold, and release) in the oral cavity with the passage to the nasal cavity open. Nasals, along with plosives, are universal consonants found in most languages. Maddieson (1984: 61) states that nearly 97% of languages have at least one nasal phoneme, and this percentage increases to 98.7% in Lee (2023: 196). On average, 3.5 nasals per language function as distinctive units, constituting approximately 17.5% of the consonant inventory. Nasals are the most common consonants next to plosives, of which at least two exist as phonemes in every language (Lee 2022).

Like other consonants, nasals are primarily found in major places of articulation such as bilabial, dental/alveolar, and velar.[1] However, the velar nasal has been noted as distinct from bilabial and dental/alveolar nasals. Velar nasals occur less frequently in languages, and their distribution within syllables or words is more limited. In the WALS (https://wals.info/feature), although other nasals are not covered, a separate chapter is dedicated to the representative velar nasal /ŋ/, and its general trends are briefly examined (Anderson 2013).

Nevertheless, velar nasals have not been thoroughly examined in previous discussion. Descriptions of velar nasals in introductory texts and other works are often unsatisfactory, with focus limited mainly to /ŋ/. There is a lack of systematic

[1] In most languages, only one of the dental nasals or alveolar nasals exists as a phoneme. For example, less than 3% of languages have both /n/ and /n̪/ as phonemes. Therefore, it seems more appropriate to combine them into one.

research on how velar nasals differ from other nasal consonants. More comprehensive research is needed to understand velar nasals functioning as phonemes, especially through typological studies based on extensive language data. The goal of this study is to analyze velar nasals across as many languages as possible and to elaborate on the typological phonology of velar nasals.

This paper is organized into five main sections. Section 2 provides a brief introduction to the language samples used in this study. The remaining sections cover four typological topics concerning velar nasals. In section 3, the various types of velar nasals found in languages worldwide are described. This serves as a foundation for the investigation of velar nasals. Section 4 focuses on analyzing the nasal inventories of individual languages. The quantity and proportion of velar nasals within these inventories, as well as the preferred types of velar nasals are discussed. Section 5 is devoted to exploring the distinctions between velar nasals and other major nasal consonants. Through several comparative criteria, the characteristic features of velar nasals are identified, and their significance is elucidated. Finally, section 6 delves into the distributional constraints of the velar nasal /ŋ/ within syllables. It establishes three types based on whether /ŋ/ functions as an onset and/or coda, and the regional distribution of each type is investigated.

2. Language data

The significance of language samples in typological research cannot be overemphasized (Bickel 2007, Hyman 2007, Maddieson 2023). This study focuses on nasal inventories of 1,411 languages, which are based on Lee's (2023) language sample. Lee (2023) covered 1,416 languages, but after excluding five double-included languages, the resulting sample consists of 1,411 languages. Information such as language names and family classifications are sourced from Glottolog (Hammarström et al. 2024). Languages are assigned to families in proportion to Glottolog's classification, so the larger the language family is, the more languages are included. To ensure diversity, we include at least one language from each of the 214 top-level families.

In order to prevent bias in language samples, it is also necessary to avoid skewing toward certain regions. It is convenient to judge this issue in terms of macro-areas. Glottolog sets six macro-areas (Africa, Papunesia, Eurasia, South America, North America, Australia), but since the languages of Asia and Europe differ considerably, this study distinguishes seven macro-areas.

Table 1 Distribution of languages by macro-area

region	Africa	Papunesia	Asia	S. America	N. America	Europe	Australia
languages	350	328	307	153	135	80	58

Language distribution in Table 1 is proportional to the number of languages spoken in each macro-area. As can be seen above, this study paid special attention to the construction of the language samples to resolve problems caused by bias toward language families or regions. In addition, from a statistical perspective, the

very large size of the language sample also contributes to reducing the problem of bias. By dealing with large-scale language data, this study minimizes the challenges typically associated with data bias.

The phoneme inventories for each language were taken from previous works, such as books, dissertations, and articles. In cases where there were multiple studies on a language, the one judged to be more reliable was selected. The nasal phonemes extracted from the consonant inventories were organized in a consistent way by transcribing them into IPA symbols. Marginal phonemes accepted through borrowing were all excluded. Since these foreign phonemes are mainly used in loanwords, including them can distort the characteristics of the languages. Finally, abstract segments such as archiphonemes were not included in the phoneme inventory. One such example is a nasal unspecified for place of articulation, which in some languages is only set at the underlying level.

3. Types of velar nasals

There are nine velar nasals that function as phonemes found in the language samples. As will be seen in section 5, the inventory size of velar nasals is smaller than that of other major nasals, such as bilabial or dental/alveolar nasals.

(1) Inventory of velar nasals ordered in terms of language frequency

ŋ (883), ŋʷ (52), ŋ̊ (34), ŋʰ (8), ˀŋ (8), ŋʲ (4), ˀŋʷ (3), ŋˀ (1), ᵏŋ (1)

(1) shows the nine velar nasals along with their language frequency in parentheses.[2] These velar nasals can be classified by three criteria: phonation type, secondary articulation, timing relationship of oral closure and velic state.

(2) Classification of velar nasals

a. Phonation type: / ŋ, ŋʷ, ˀŋ, ŋʲ, ˀŋʷ, ŋˀ, ᵏŋ / ⇔ / ŋ̊ / ⇔ / ŋʰ /
b. Secondary articulation: / ŋ, ŋ̊, ŋʰ, ᵏŋ / ⇔ / ŋʷ, ˀŋ, ŋʲ, ˀŋʷ, ŋˀ /
c. Timing relationship: / ŋ, ŋʷ, ŋ̊, ŋʰ, ˀŋ, ŋʲ, ˀŋʷ, ŋˀ / ⇔ / ᵏŋ /

In (2a), velar nasals are divided into three categories (voiced, voiceless and aspirated) according to the phonation type related to the use of the laryngeal system.[3] Phonation types vary depending on the discussion, but regardless of which one is based on, velar nasals are relatively simple. Compared to the different phonation types presented in, for example, Ladefoged & Maddieson (1996: 106) or Gordon & Ladefoged (2001: 384), there are categories that are not found in the velar nasals. On the other hand, as will be confirmed in section 4, nasals at other places of articulation exhibit more diverse phonation type.

[2] In the discussion below, numbers in parentheses indicate language frequencies unless otherwise specified.

[3] In some languages, including Indo-Iranian languages, voiced aspirated consonants are often described as breathy-voiced, so it is valid to classify /ŋʰ/ as a category based on phonation type.

(2b) is a classification of velar nasals by the presence or absence of secondary articulation. Secondary articulation is a lesser degree of stricture produced simultaneously with primary stricture, and several types are found in nasal consonants.[4] However, velarization cannot accompany velar nasals due to articulatory overlap, and pharyngealization has extremely limited combination with nasals. As a result, the types of secondary articulations found in velar nasals are quite simple. (2b) contains five velar nasals accompanied by the secondary articulation, and the labialized velar nasal (/ŋʷ/) has an overwhelmingly high language frequency. Velar nasals with secondary articulations other than labialization are rare, found in less than 1% of languages.

The timing relationship in (2c) refers to the velic state during which oral closure is maintained when pronouncing nasals. Laver (1994: 228) distinguishes six classes (simplex oral stop, complex pre-nasal oral stop, complex post-nasal oral stop, simplex nasal stop, complex pre-occluded nasal stop, complex post-occluded nasal stop), and among the three types of nasals, post-occluded nasal is not identified at the phoneme level. In simplex nasal, the velic state is open while the oral cavity is closed, whereas in pre-occluded nasal, the velic state is closed during the first half of oral closure. The only velar nasal in the latter category is / ᵏŋ /.

Now, let us delve into a detailed examination of the nine velar nasals listed in (2). First, /ŋ/ stands out as the most prototypical velar nasal. Across various places of articulation, plain consonants, which are less complex and easier to articulate, typically serve as unmarked members and are prevalent in terms of language frequency and regional distribution. Velar nasals conform to this pattern. The voiced plain nasal /ŋ/ exhibits an overwhelming frequency, being present in nearly two-thirds of languages, 62.6% (883/1,411).[5] Despite its widespread occurrence, /ŋ/ has considerable variation in its distribution across regions, which is generally unexpected for high-frequency consonants.

Table 2 Percentages of languages with /ŋ/ by region (macro-area)

region	languages	languages with /ŋ/	percentage
Australia	58	58	100%
Asia	307	261	85.0%
Africa	350	254	72.6%
Papunesia	328	225	68.6%
Europe	80	31	38.8%
South America	153	29	19.0%
North America	135	25	18.5%

[4] Among the secondary articulations presented here, laryngealization is related to the action of the glottis and seems to be classified as a phonation type. However, it can be viewed as a secondary articulation if, as in Laver (1994: 330), the emphasis is on a secondary stricture at the glottal level.

[5] Following /ŋ/, the next most common nasal, /ŋʷ/, is found in only 3.7% (52/1,411) of languages.

Table 2 provides a summary of the percentage of languages with /ŋ/ by region. Among Australia's indigenous languages, /ŋ/ appears in every phoneme inventory, reflecting a remarkable linguistic consistency despite its extensive geographic spread. Similarly, languages in Asia exhibit a high likelihood of including /ŋ/ as a phoneme, 85.0%, well surpassing the average. In contrast, the languages of Europe and the Americas have a much lower percentage of /ŋ/ in their phoneme inventories. A particularly striking observation is that over 80% of indigenous languages in South and North America lack /ŋ/. This strong correlation between the presence or absence of the phoneme /ŋ/ and its regional distribution underscores its potential utility in areal linguistics.

The /ŋ̊/ is characterized as voiceless despite being nasal. Unlike obstruents, sonorant consonants, including nasals, do not actively engage vocal cord vibrations for phonemic contrast and are predominantly voiced. Consequently, voiceless nasals are notable, and their occurrence in languages is considerably lower than that of voiced nasals. Voiceless nasals are known to be common in many languages across Southeast Asia (Bhaskararao & Ladefoged 1991). This is confirmed in Figure 1, which indicates that 28 out of the 34 languages with /ŋ̊/ as a phoneme are found in this region. In other regions, the presence of /ŋ̊/ is sporadic. This distributional pattern is consistent with the occurrence of voiceless nasals in other places of articulation.

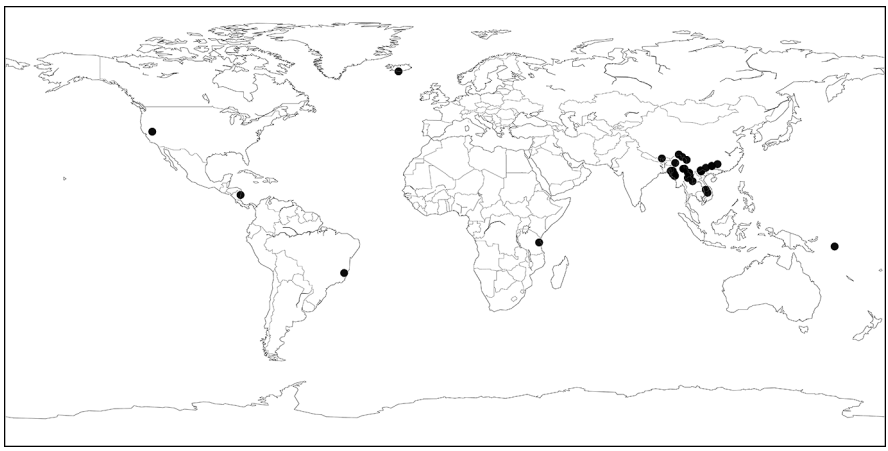

Figure 1 Distribution map of /ŋ̊/

The aspirated velar nasal (/ŋʰ/) is a nasal consonant followed by a puff of breath. Unlike plosives, nasals are not found to be preceded by aspiration. The aspiration transition in nasals is not as distinct as that in plosives (Rabha et al. 2019). The regional distribution of this consonant closely resembles that of voiceless nasals in Figure 1. Furthermore, no language has both voiceless nasal and voiced aspirated nasal as separate phonemes. These facts suggest that voiceless nasals and aspirated

nasals share many phonetic features, which makes it unlikely that both classes could serve a distinct function in the same language.

The labialized velar nasal, /ŋʷ/, has the highest language frequency among the labialized nasal consonants. In fact, peripheral nasals that are pronounced at both ends of the mouth, such as velar nasals and bilabial nasals, have in common that labialization has the highest frequency among the secondary articulations. The tendency that labialization favors bilabials and velars, especially velars, is also clearly confirmed in plosives.[6] The distribution of /ŋʷ/ is mainly concentrated in Africa. Of the 52 languages with this consonant, 36 are located in Africa.

The laryngealized nasals /ˀŋ/ and /ŋˀ/ are both accompanied by glottal constriction, but differ in its position, i.e. whether laryngealization precede or follow the primary articulation.[7] Laryngealization, along with aspiration, can occur both before and after consonants.[8] However, the pre-laryngealized nasal is found in more languages: /ˀŋ/ (8), /ŋˀ/ (1). This trend is paralleled by the fact that pre-laryngealized plosives are predominantly voiced rather than voiceless (Lee 2022: 104). Since most nasals, including velar nasals, are voiced, they are more often preceded by laryngealization. Laryngealized velar nasals are primarily found in Asia, particularly in and around southwestern China.

Not mentioned among the velar nasals accompanying secondary articulation in (2b) are two (/ŋʲ/, /ˀŋʷ/) that are found in only a few languages. The palatalized velar nasal is much less common than palatalized bilabial or dental/alveolar nasals. As will be seen in section 5, palatalized bilabial and dental/alveolar nasals are as frequent in languages as voiceless nasals, but this is not the case for velar nasal. This is quite different from palatalization in plosives. Palatalized plosives are almost evenly distributed in bilabials, dentals/alveolars, and velars (Lee 2022: 99), but there is considerable variation in nasals. Finally, /ˀŋʷ/ stands out from the other velar nasals because it is accompanied by two secondary articulations. Overall, the combination of two secondary articulations is exceedingly rare in nasals. This consonant is found only in the Tai-Kadai language family, located in Asia.

The pre-occluded nasal /ᵏŋ/ is a class distinguished by the time relationship between oral closure and velic opening, with the passage into the nasal cavity being closed earlier in the articulatory process (Laver 1994). Urim, a language spoken in Papunesia, has three pre-occluded nasals as phonemes (Luoma 1985). Several

[6] In the labialization of plosives, the preference for velar is much stronger than that of nasals. Concretely, according to Lee (2022: 95), the ratio of labialized plosives is in the hierarchy of 'velar (66.1%) > bilabial (18.4%) > dental/alveolar (6.8%)', while for nasals, it is in the hierarchy of 'velar (46.2%) > bilabial (38.7%) > dental/alveolar (6.7%)'.

[7] Laryngealized nasals have a constriction of the glottis, but they do not have as much air pressure as stop consonants (Kingston 1983; Plauché et al. 1998). Laryngealized nasals (/mˀ, nˀ, ŋˀ/) need to be distinguished from glottalized nasals (/m', n'/). For their differences, see note 14) in section 5.

[8] Since it is not at all the case that a language has distinct phonemes that differ only in the position of laryngealization, it is possible not to distinguish between /ˀŋ/ and /ŋˀ/. However, in order to show the diversity of phonemes typologically, we will present them separately.

discussions of this language agree on the existence of pre-occluded nasals. In Urim, the allophones of the pre-occluded nasals are realized as voiceless word-finally.

4. Velar nasals in the nasal inventory

In this section, we examine the velar nasal inventory. The primary objective is to explore both the quantitative and qualitative aspects of velar nasals within the nasal inventory. We will go into detail regarding the number and preferred types of velar nasals present in each language. Before further discussion, it is necessary to summarize how many nasals function as phonemes in the consonant inventory.

Table 3 Language distribution by number of nasals

nasals	languages	nasals	languages
0	18	5	119
1	14	6	49
2	272	7	11
3	451	8	26
4	440	9~18	11

As shown in Table 3, the number of nasals exhibits considerable variation across languages. However, most languages feature between two and five nasals, with three or four being the most common. Over 90% of the language samples fall within this range. Beyond this range, the number of languages decreases significantly. On average, a language tends to have approximately 3.5 nasals. Even when excluding languages that lack nasals as phonemes, the increase in the average number is marginal due to the scarcity of such languages.

Languages with no or only one nasal are notably common in South America and North America.[9] These regions include 13 of the 18 languages without a nasal, and 8 of the 14 languages with one nasal. On the other hand, none of the European or Australian languages fall into this category, and only one Asian language does. Additionally, the sizes of the consonant inventories in these languages are smaller than average. Excluding semivowels, consonant inventories have an average of 20.2 phonemes, but among languages with no or one nasal consonant, the majority fall below this average, averaging only 14.3 consonant phonemes. An exceptional case is Quileute, a language spoken in North America, which has no nasals despite having 31 consonants (Maddieson 1984: 379).

Even in languages with relatively many nasals, something unusual is found. In Table 3, if we classify 48 languages with 7 or more nasals, more than twice the average, by region, the overwhelming majority (32 languages) are spoken in

[9] If there is no nasal in the phoneme inventories, it is common for it to exist as an allophone of other consonants such as plosives. However, Abawiri, a language of Lakes Plain in Papunesia, is very striking in that nasals themselves do not exist, either as phonemes or as allophones (Yoder 2020: 36).

Asia. Furthermore, all languages with more than 10 nasals are distributed in Asia. Languages with 7 or more nasals tend to have large consonant inventories, with an average of 37.0 consonants as phonemes.

From the observations above, it becomes evident that languages with either too few or too many nasals exhibit distinctive characteristics regarding regional distribution and the size of the consonant inventory. Languages with very few nasals are predominantly found in the Americas, whereas languages with a high number of nasals are concentrated in Asia. Moreover, languages with few nasals have consonant inventories that are approximately 70% of the average, while languages with many nasals have consonant inventories that are more than 1.6 times the average. The Pearson correlation coefficient (PCC) between the size of the consonant inventory and the nasal consonant is 0.498 ($p<0.000$), which indicates a statistically significant relationship, but this does not establish a very strong correlation. This statistical analysis matches well with the language distribution in Table 3. For any consonant class, if the size of the consonant inventory is large, its member is likely to increase. However, nasals are present in most languages regardless of consonant inventory size, so the correlation between them is not very strong.

Now let us shift our focus to the topic of this section, velar nasals in the nasal inventory.

(3) Number and percentage of velar nasals in the nasal inventory
   a. number: 994/1,411 = 0.7
   b. percentage: 0.7/3.5 = 20.0%

In the language sample, 994 velar nasals are identified as phonemes, with an average of 0.7 per language. Considering that the average number of nasals overall is approximately 3.5, velar nasals only represent 20% of the total. Given that the velar is one of the three major places of articulation for consonants, along with the bilabial and dental/alveolar, this percentage may be considered relatively low, and this will be confirmed again in Table 11.

The number of velar nasals across languages have the following distribution.

Table 4 Language distribution by number of velar nasals

velar nasals	languages	average number of nasals
0	519	2.49
1	799	3.84
2	86	6.29
3	5	12.40
4	2	16.00

Table 4 shows how many velar nasals occur in languages that have nasals as phonemes. It is most common to find one velar nasal per language. Well over half of the sampled languages, 799, have only one velar nasal, but 519 languages have no velar nasal, which is also a large group. In contrary, languages with two or more

velar nasals are relatively scarce, totaling only 93. In Table 4, it can be seen that as the number of velar nasals increases, the average number of nasals increases. The number of velar nasals is correlated to the size of the nasal inventory. Indeed, the PCC between these two values is 0.724 ($p<0.000$), indicating a very strong proportional relationship.[10]

As mentioned previously, velar nasals are considered one of the most significant classes of nasals, along with bilabial and dental/alveolar nasals. However, it is noteworthy that there is a relatively high percentage of languages lacking any velar nasals, 36.8% (519 out of 1,411). In other words, at least one of every three languages does not have a velar nasal. This is remarkably high considering that in the language sample, only 29 languages do not have bilabial nasals and 27 languages do not have dental/alveolar nasals.[11]

The absence of velar nasals in languages exhibits a clear regional bias, closely correlated with the distribution outlined in Table 2. Given that /ŋ/ is the most prevalent velar nasal, the regional distribution or the percentage of languages lacking /ŋ/ closely mirrors that of language without velar nasals. This correspondence is verified in Table 5, where the percentages are nearly the reverse of those in Table 2.

Table 5 Percentages of languages without velar nasals

region	languages	languages without velar nasal	percentage
North America	135	110	81.5%
South America	153	124	81.0%
Europe	80	49	61.3%
Papunesia	328	103	31.4%
Africa	350	88	25.1%
Asia	307	45	14.7%
Australia	58	0	0%

Interestingly, the percentages in Table 5 are inversely proportional to the average numbers of nasals presented in Lee (2023: 197).

[10] Bilabial and dental/alveolar nasals also have high PCCs with the size of the nasal inventory (0.717 and 0.679, respectively), but not nearly as high as the velar nasals. Interestingly, there is a notable imbalance in the correlations of inventory sizes between bilabial, dental/alveolar, and velar nasals. The PCC between bilabial and dental/alveolar nasals is as high as 0.678, indicating that these nasals are positively correlated with each other in terms of inventory sizes. On the other hand, the PCCs of these two and velar nasals are 0.321 and 0.270, respectively, showing a relatively weak correlation in inventory size.

[11] In previous discussions, it has also been reported that bilabial nasals or dental nasals appear in far more languages than velar nasals (Crother 1975, Maddieson 1984, Gordon 2016).

Table 6 Average numbers of nasals in Lee (2023)

region	Australia	Asia	Africa	Europe	Papunesia	N. America	S. America
average	5.0	4.3	3.8	3.2	3.0	2.8	2.7

Comparison of Table 5 and Table 6 reveals a strong correlation: the greater the average number of nasals, the lower the percentage of velar nasal absence, and vice versa. For instance, in Table 5, all Australian languages feature velar nasals, and in Table 6, their nasal consonants are the most abundant, with an average number of 5.0. Conversely, approximately 80% of the languages in the Americas have no velar nasals, and the average number of nasals is the smallest, less than three.

(4) Correlation between the number of nasals and languages without velar nasals

	Australia	Asia	Africa (Europe/Papunesia)	America
nasals	more	←----------	----------→	less
languages without velar nasals	less	←----------	----------→	more

(4) shows schematically that there is close relationship between the presence or absence of velar nasals and the size of the nasal inventory, except in Europe and Papunesia. This robust correlation is due to the fact that there are quite a few languages without velar nasals. If the language frequency of velar nasals is very high, they will be present in most languages regardless of the size of the nasal inventory, but if not, a larger inventory of nasals is more likely to include the velar nasal than a smaller inventory.

There is a clear preference for the velar nasal inventory. Among the 799 languages with only one velar nasal, /ŋ/ appears in most cases, as expected. The only exceptions are Daba and Mazagway, which have /ŋʷ/ instead of /ŋ/ as the only velar nasal (Lienhard & Giger 2009).[12] In both languages, there are three nasal consonants (/m, n, ŋʷ/), and /m, n/ have no phonotactic restrictions, but /ŋʷ/ appears only word-finally. It is not surprising that /ŋ/ appears in languages having only one velar nasal, with very few exceptions. This result is explained by the fact that among the velar nasals, /ŋ/ occurs in the largest number of languages and is phonologically unmarked.

Very rarely, a language with a velar nasal as its only nasal has been reported. Pfurtscheller (2012: 23) argued that although there is disagreement, /ŋ/ can be established as the only nasal consonant in Láá Láá Bwamu, an African language. Ferguson (1963: 57) stated that /n/ appears in languages with only one nasal. However, some of the languages in this study have /ŋ/ (Láá Láá Bwamu), or /m/ (Halkomelem, Konai, and Toaripi) as the only nasal consonant (Årsjö 2016,

[12] These two languages are geographically adjacent and linguistically close enough that they are sometimes treated as dialects.

Brown 1972, Galloway 1977). Maddieson (1984: 62) pointed out that Taoripi and Mixtec have /m/ and /ŋ/ as their only nasals, respectively.

Among languages with two velar nasals, all but Lachi have /ŋ/ in common.[13] Therefore, it is the other velar nasal that combines with /ŋ/ that determines the preferred inventory. There are five inventories of velar nasals that occur repeatedly in two or more languages.

Table 7 Preferred inventories in languages with two velar nasals

inventory	/ŋ, ŋʷ/	/ŋ, ŋ̊/	/ŋ, ŋʰ/	/ŋ, ˀŋ/	/ŋ, ŋʲ/
languages	40	30	8	3	3

In Table 7, two inventories stand out. /ŋ, ŋʷ/ is the most dominant, appearing in 40 languages, and /ŋ, ŋ̊/ is also very frequent, appearing in 30 languages. There are 84 languages with two velar nasals in Table 4, so these two types are prominent, being present in more than 80% of languages. The language frequencies of the inventories in Table 7 are consistent with those of the velar nasals in (1). The high frequency inventories in Table 7 include /ŋʷ/ and /ŋ̊/, in that order, after /ŋ/ in (1).

Only a small number of languages have more than three velar nasals. They all have /ŋ/, and many of them have either a voiceless nasal /ŋ̊/ or a laryngealized nasal /ˀŋ/. However, due to the limited number of languages, it is difficult to attribute great importance to this. In Table 7, /ŋʷ/ appears more often than /ŋ̊/ or /ˀŋ/, but this trend is not consistent among languages with three or more velar nasals. This discrepancy is likely due to the fact that languages with a higher number of velar nasals are predominantly found in Asia, while /ŋʷ/ is more prevalent in African languages.

As shown in Table 4, it is common for a language to have a single velar nasal. Only a few languages possess more than two velar nasals. The percentages of these languages by region are inversely proportional to those in Table 5, albeit with some differences.

Table 8 Percentages of languages with two or more velar nasals

region	languages	languages with two or more velar nasals	percentage
Asia	307	45	14.7%
Africa	350	30	8.6%
Europe	80	3	3.8%
Papunesia	328	10	3.0%
South America	153	3	1.9%
North America	135	2	1.5%
Australia	58	0	0%

[13] According to Kosaka (2000: 19), in Lachi, /ŋ/ is only found in borrowed words, making it a marginal phoneme. As mentioned in section 2, all marginal phonemes are excluded from the phoneme inventory in this study.

The percentage of languages with two or more velar nasals in Table 8 generally increases as the percentage of languages without velar nasals in Table 5 decreases. The higher percentage of languages in Asia or Africa and the lower percentage of languages in the Americas in Table 8 fit well with this trend. However, there are exceptions, such as Australia. Although all Australian languages have velar nasals, none of them possess two or more velar nasals. This peculiarity arises from a typological feature of Australian languages. In Australian languages, consonant phonemes tend to be distributed across a variety of places of articulation, particularly in the coronal region. For example, a relatively high proportion of Australian languages have retroflex nasals or palatal nasals, and there are a number of languages in which both dental and alveolar nasals function as separate phonemes. However, it is rare for multiway opposition by the phonation type or secondary articulation. Consequently, there is typically only one nasal per place of articulation, which is well reflected in Table 8.

5. Contrast between velar nasals and other major nasals

In reviewing the types, numbers, and proportions of velar nasals, it was partially indicated that velar nasals are inferior to nasal in other major places of articulation. While this has been noted before, there has rarely been a detailed examination of the extent of this difference in some respects. In this section, we will set up four criteria for comparison to explore how the three major nasals (bilabial, dental/alveolar, and velar) are distinguished. These comparisons will aid in understanding the characteristics of velar nasals.

(5) Comparison criteria for major nasals
   a. variety of types
   b. language frequency
   c. percentage in the nasal inventory
   d. implicational relationship between major nasals

(5a) pertains to the differentiation of nasals based on phonation type, secondary articulation, velic state, etc. The outcomes of this comparison within the framework in (2) are summarized in Table 9.

Table 9 Variety of nasal types

		bilabial	dental/alveolar	velar
phonation type	Voiced	/m/	/n/	/ŋ/
	Aspirated, Breathy	/mʰ, m̤/	/nʰ, n̤/	/ŋʰ/
	Voiceless	/m̥/	/n̥/	/ŋ̊/
	Glottalized[14]	/m'/	/n'/	(×)
secondary articulation	Single	/mʷ, mʲ, ˀm, mˤ/	/nʲ, nʷ, ˀn, nˤ, nˠ/	/ŋʷ, ŋʲ, ŋˀ/
	Multi	/ˀmʲ, mʰʷ, …/	/ˀnʲ/	/ˀŋʷ/
timing relationship	Pre-occluded	/ᵖm/	/ᵗn/	/ᵏŋ/
tenseness	Fortis	/mm/	/nn/	(×)

In Table 9, all eight types of bilabial or dental/alveolar nasals are present, whereas only six types of velar nasals are represented. Moreover, there is no unique type of velar nasal that is not found in other major places of articulation. The two absent types of velar nasals are not main members and are found only in a few languages. Nevertheless, Table 9 effectively illustrates that the articulatory types for velar nasals are less diverse than those of nasals in other major places of articulation. This limited diversity of velar nasals is also evident in the combinations with secondary articulations. There are relatively few types of secondary articulations accompanying velar nasals. For instance, there are no velar nasals that combine with velarization and pharyngealization, whereas bilabial or dental/alveolar nasals are accompanied by them, albeit rarely.

(5b) serves as a criterion for assessing the number of languages in which nasals appear as phonemes. The language frequency of nasals varies considerably by their place of articulation. Furthermore, the types of high-frequency nasals differ slightly depending on the place of articulation.

[14] Glottalized nasals (/m', n'/) differ from laryngealized nasals (/mˀ, nˀ, ŋˀ/) in two aspects. First, geographically, glottalized nasals are found exclusively in North America, while laryngealized nasals appear sporadically in several regions, mainly in Asia. Because of this difference in regional distribution, it has never been reported that a language has both glottalized and laryngealized nasals as separate phonemes. Second, glottalized nasals most often coexist with ejective obstruents (Maddieson 2013), whereas this is not the case for laryngealized nasals. However, the difference between glottalized and laryngealized nasals may just be a matter of the tradition of description, as pointed out by an anonymous reviewer. That is, we cannot rule out the possibility that in the American tradition they are described as 'glottalized nasals' while in others the same sounds are described as 'laryngealized nasals'.

Table 10 High-frequency nasals

ranking	bilabial	dental/alveolar	velar
1	/m/ (1,382)	/n/ (1,384)	/ŋ/ (883)
2	/m̥/ (46)	/n̥/ (46)	/ŋʷ/ (52)
3	/mʷ/ (43)	/nʲ/ (51)	/ŋ̊/ (34)
4	/mʲ/ (33)	/nʰ/ (20)	/ˀŋ, ŋˀ/ (9)
5	/mʰ/ (22)	/nˀ/ (19)	/ŋʰ/ (8)

Table 10 presents the top five high-frequency nasals for each place of articulation, along with their language frequencies. Velar nasals are distinct from bilabial and dental/alveolar nasals in two ways. First, they exhibit a lower language frequency. Except for that with the second highest frequency, /ŋʷ/, velar nasals are found in fewer languages than other nasals of the same rank. The notability and consistency of this difference suggest that it is not merely coincidental. Second, the ranking of high-frequency consonants for velar nasals is distinct. While bilabial nasals and dental/alveolar nasals may not consistently align, they generally adhere to a hierarchy of 'voiced plain nasals > voiceless plain nasals > nasals with secondary articulation'. For velar nasals, on the other hand, a labialized nasal has a higher frequency than a voiceless nasal. This peculiarity is due to the fact that labialization exhibits a very strong preference for velar stops (plosive and nasal), as mentioned in section 3. Consequently, the frequency of /ŋʷ/ surpasses that of /ŋ̊/.[15]

(5c) is a criterion for the proportion of nasals, specifically concerning how the percentage of nasals varies by place of articulation. It can be inferred from Table 10 that the percentage of velar nasals is relatively low.

Table 11 Percentages of nasals within the nasal inventory

bilabial	dental/alveolar	Velar	other
31.7%	31.9%	20.0%	16.4%

As shown in Table 11, nasals across the three major places of articulation constitute a substantial proportion, 83.6%, of all nasals. Even when combining all nasals other than these three major places of articulation, their collective total is less than that of velar nasals. There is no significant difference in the percentage between bilabial nasals and dental/alveolar nasals, both of which dominate over other nasals. However, the percentage of velar nasals is only approximately two-thirds of each of these two nasals.

Tables 9 through 11 collectively illustrate that velar nasals are clearly inferior to bilabial and dental/alveolar nasals, both quantitatively and qualitatively. One might wonder if the relative scarcity of the velar nasal is not limited to nasals, but is also present in other manners of articulation. That is, all velar consonants may be less diverse and less frequent than bilabial or dental/alveolar consonants. However,

[15] The absence of /nʷ/ in the list of high-frequency dental/alveolar nasals can also be attributed to the favored place of articulation for labialization.

this prediction does not seem to be reasonable. In the case of plosives, which share a similar articulatory process of closure-hold-release with nasals, the velar is not inferior to other major places of articulation. According to Lee (2022: 183), velar plosives have a language frequency and type diversity equal to or even higher than bilabial and dental/alveolar plosives.[16] Therefore, the inferiority of the velar nasals in (5a–c) do not solely arise from the fact that they are articulated in the velar.

(5d) is related to the implicational relationship between nasals, indicating how much the presence of nasals in one place of articulation implies the presence of nasals in another place of articulation. The implicational relationship can be used to determine which place of articulation is more unmarked/marked in nasals. Croft (2003: 159) states that in the language sample of UPSID, 1) 99.0% of languages with nasals have /n/, 2) the percentage of /m/ implying the presence of /n/ is 99.3%, and 3) the percentage of /ŋ/ or /ɲ/ implying both /m/ and /n/ is 98.5%; a hierarchy of places of articulation is also suggested, such as 'dental/alveolar < bilabial < velar'. This means that the dental/alveolar nasal is the most unmarked and that the velar nasal is the most marked. This conclusion appears to hold in general.

Table 12 Percentages of implications between nasals

⇒	bilabial	dental/alveolar	velar
bilabial	-	97.2%	64.3%
dental/alveolar	99.3%	-	64.6%
velar	99.3%	97.8%	-

In Table 12, '⇒' indicates the direction of the implicational relationship. The vertical line of the table represents the implicant on the left side of '⇒' and the horizontal line represents the implicand on the right side of '⇒'. The percentage of implications illustrates the direction of the implicational relationship between bilabial, dental/alveolar, and velar nasals. For velar nasals, the direction of the implicational relationship is clearly different. In other words, the percentage of cases in which velar nasals imply the presence of bilabial or dental/alveolar nasals is much greater than that of the reverse direction. This reaffirms that velar nasals are more marked than bilabial or dental/alveolar nasals. The percentage of implications between bilabial and dental/alveolar nasals is higher in 'dental/alveolar ⇒ bilabial' than in 'bilabial ⇒ dental/alveolar', but the difference between the two is not large. Thus, it appears difficult to definitively determine which of the bilabial and dental/alveolar nasals is more marked, contrary to Croft's hierarchy.

A crucial factor contributing to the percentages in Table 12 is that, as dem-

[16] Strictly speaking, only the voiceless velar plosive /k/ is equal to or more dominant than /p/ or /t/, while the voiced velar plosive /g/ is inferior to /b/ and /d/ (Gamkrelidze 1975: 236, Lee 2022: 266). Some aerodynamic properties are involved in the relative inferiority of /g/ over /k/ (Ohala 1983: 194–201). However, the difference between /g/ and other major voiced plosives (/b/, /d/) is not that great compared to that of the nasals.

onstrated in Table 10, bilabial and dental/alveolar nasals are present in most languages, while velar nasals are absent in a significant number of languages. Therefore, when bilabial nasals or dental/alveolar nasals serve as the implicand, the percentage of implications is bound to be very high regardless of the phonemes present in the implicant. On the other hand, if bilabial or dental/alveolar nasals are placed in the implicant, the percentage of implications is likely to be low unless the implicand contains phonemes with a frequency as high as that of bilabial and dental/alveolar nasals. This disparity is well reflected in Table 12.

Thus far, we have compared nasals across the three major places of articulation based on four criteria. Velar nasals are notably distinct from bilabial and dental/alveolar nasals. The variety of types of velar nasals is relatively limited, and their language frequency and percentage in the nasal inventory are much lower than those of other major nasals. In terms of the direction of implication, they only exhibit a one-sided relationship with other nasals. These findings collectively indicate that the velar nasal is both marked and inferior, which can be understood acoustically.

Velar nasals are not as perceptually advantageous as other nasals, and this is confirmed in many experiments. Several acoustic properties of velar nasals are involved in this. First, as mentioned by Nartey (1979: 31), nasal resonance and formant transition in adjacent vowels play important roles in the perception of place of articulation of nasals. The former is highly favorable for bilabial nasals and the latter for dental/alveolar nasals. In contrast, few acoustic cues have been identified that favor velar nasals. Second, velar nasals are phonetically more similar to nasalized vowels than other nasals (Ohala 1975: 297), i.e., the resonating cavity of velar nasals is relatively closer to that of nasalized vowels. As a result, velar nasals may change into nasalized vowels more frequently than other nasals. Third, the antiresonance of velar nasal is placed in the high frequency which is severely attenuated in nasals (Ohala 1975: 292). This makes velar nasals less evident perceptually.

Certainly, the velar nasal is less prominent than other nasals due to its acoustic characteristics. This makes the velar nasal more prone to confusion with other sounds and susceptible to phonological changes into similar segments, such as nasalized vowels. (Ohala 1975, Nartey 1979, Ohala & Ohala 1993). It seems that these factors have contributed to the limited variety and low language frequency of velar nasals, rendering them more marked.

6. Phonotactics of velar nasals

It has been noted early on that the velar nasal represented by /ŋ/ is phonotactically constrained. The fact that /ŋ/ does not occur at the beginning of a word in the widely known major languages of the Indo-European language family has led to the misunderstanding that this is a universal property. However, in many languages, /ŋ/ does not seem to have severe distributional constraints. For instance, according to Anderson (2013), 48 out of the 100 basic languages in the WALS have /ŋ/ as a phoneme, and in 32 of them, /ŋ/ can occur word-initially. In other words, there are far more languages where /ŋ/ occurs at the beginning of a word

than where it does not, suggesting that it is more common for /ŋ/ to be phonotactically unrestricted.

We aim to broaden the scope of the target language and thoroughly investigate whether /ŋ/ is realized at syllable onset. The rationale behind focusing solely on /ŋ/ is the lack of comprehensive understanding regarding the distribution of other velar nasals. Among the 883 languages that have /ŋ/ as a phoneme, 481 provide a clear description of its distribution within syllables. The extent to which /ŋ/ is manifested at syllable onset and/or in a coda is summarized in Table 13.

Table 13 Language types by the distribution of /ŋ/ within syllables[17]

type	both onset and coda	only onset	only coda
languages	391	37	53

Table 13 indicates a notably high percentage of languages in which /ŋ/ appears both at syllable onset and in the coda, meaning that there are significantly more languages where /ŋ/ is not restricted phonotactically than languages where it is. Additionally, there are 37 languages in which /ŋ/ does not occur in a syllable coda but only at syllable onset. The number of languages in which /ŋ/ can be realized at syllable onset is 428 out of 481 languages. Thus, like other consonants, /ŋ/ is more likely to occur at onset, although it is slightly less prevalent. On the other hand, only 53 languages prohibit /ŋ/ at syllable onset, leading to a low percentage of 11.0%.

The distribution of /ŋ/ within syllables varies by region. The regional distribution of languages where /ŋ/ can appear at syllable onset is shown in Table 14.

Table 14 Percentages of languages with syllable-initial /ŋ/

region	languages	percentage
Australia	30	100% (30/30)
Papunesia	115	93.5% (115/123)
Asia	188	92.6% (188/204)
Africa	69	87.3% (69/79)
North America	9	64.3% (9/14)
South America	14	63.6% (14/22)
Europe	3	33.3% (3/9)

Table 14 presents the number and percentages of languages with syllable-initial /ŋ/ for each region. Interestingly, the percentages in Table 14 are very closely related to the percentages of languages lacking velar nasals in Table 5. That is, regions with lower percentages of languages lacking velar nasals in Table 5 tend to

[17] All the languages covered in this study allow consonants to appear in the syllable coda, so there are syllable types such as 'VC' or 'CVC'. In other words, there is no language in which /ŋ/ appears only at syllable onset because the syllable coda is not allowed at all.

have higher percentages of languages with syllable-initial /ŋ/ in Table 14, whereas regions with higher percentages in Table 5 tend to exhibit lower percentages in Table 14. Although this tendency is not absolute, it is quite noticeable, suggesting a direct proportional relationship between the percentage of languages with /ŋ/ as a phoneme and the percentage of languages without phonotactic restrictions on syllable-initial /ŋ/. This correlation between presence as a phoneme and phonotactics warrants further investigation to determine whether it applies to other phonemes and to explore the potential reasons behind it.

As seen earlier, there are numerous languages in which /ŋ/ occurs at syllable onset, and they are spread across various regions. However, these languages are not evenly distributed across all regions.

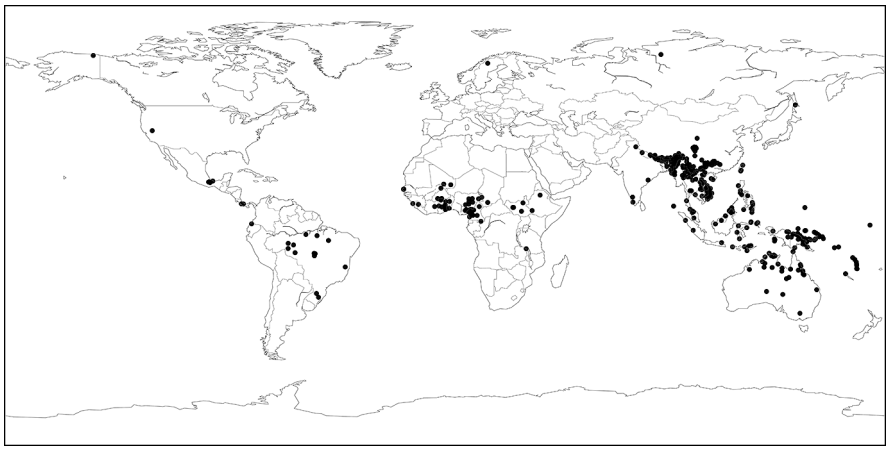

Figure 2 Distribution map of languages with syllable-initial /ŋ/

Figure 2 illustrates a biased distribution of languages across regions. In Asia, there is a notable concentration of languages on the Indochina Peninsula, while there are very few in the Middle East and Northeast. In Africa, a significant number of languages are clustered in the western region near the equator, and in Australia, in the northern region. North American and European languages are very rare. In general, it seems that languages with syllable-initial /ŋ/ are centered near the equator or at low latitudes. Conversely, the likelihood of encountering languages with syllable-initial /ŋ/ diminishes as one moves closer to higher latitudes.

Although /ŋ/ can occur at syllable onset, there is a distinction between its exclusive occurrence at onset and its occurrence both at onset and in the coda. The former is a special case compared to the latter. Nasals are the most preferred consonant class in word-final or syllable-final positions (VanDam 2004, Lee 2024). If so, languages in which nasals appear only at syllable onset are bound to be typologically less common than languages in which nasals appear both at syllable onset and in the coda. Table 15 displays the regional percentages of the 37 languages that fall into this category.

Table 15 Percentages of languages where /ŋ/ occurs exclusively at syllable onset

region	languages	percentage
North America	5	35.7% (5/14)
Australia	8	26.7% (8/30)
South America	4	18.2% (4/22)
Africa	11	13.9% (11/79)
Europe	1	11.1% (1/9)
Asia	5	2.5% (5/204)
Papunesia	3	2.4% (3/123)

In Table 15, significant variation by region is evident. A relatively high percentage of languages in North America and Australia exhibit a distribution of /ŋ/ restricted to syllable onset. In contrast, such instances are rare in the languages of Asia and Papunesia, where many languages are clustered in Figure 2.

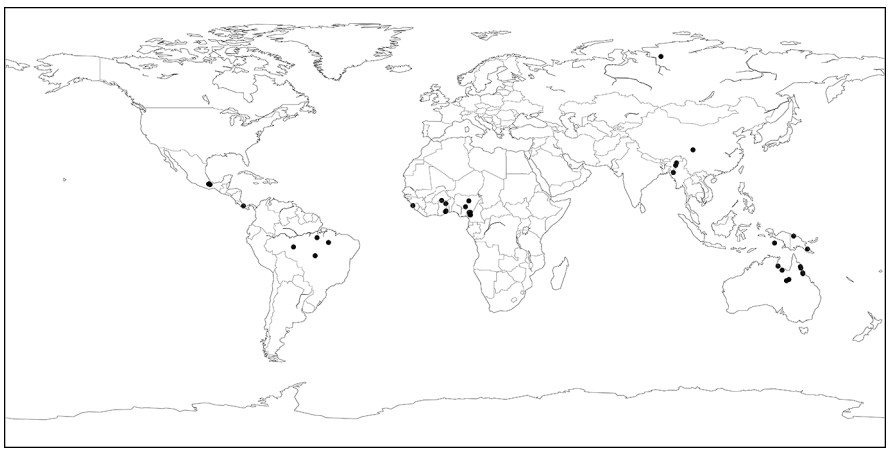

Figure 3 Distribution map of languages where /ŋ/ occurs exclusively at syllable onset

Figure 3 displays the geographical locations of the languages shown in Table 15. Due to the smaller number of languages in which /ŋ/ occurs exclusively at onset, the dots representing languages appear more sporadically in Figure 3 than in Figure 2. Nonetheless, the trend of the language distribution converging near low latitudes remains valid.

Finally, we examine the regional distribution of languages where /ŋ/ occurs only in the coda and not at onset. In Table 13, there are a total of 53 languages belonging to this category. The regional percentages of these languages can be deduced in Table 14 by subtracting the percentages of languages with syllable-initial /ŋ/ from 100; hence, it is unnecessary to present these values separately. Figure 4 shows the regional distribution of these languages.

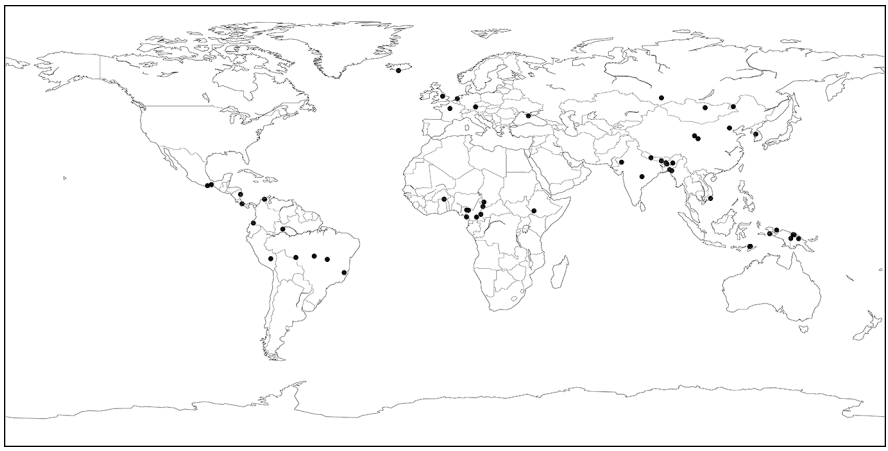

Figure 4 Distribution map of languages where /ŋ/ occurs exclusively in the syllable coda

The geographical distribution in Figure 4 is not entirely different from those in Figures 2 and 3. While the exclusive occurrence of /ŋ/ in the coda (Figure 4) and its occurrence as an onset (Figure 2, 3) are phonotactically opposite, the geographic distributions of the languages overlap to some extent. However, Figure 4 includes more languages from non-low-latitude regions. For instance, languages from Europe and Northeast Asia are sporadically represented. This difference is more clearly revealed through Gaussian kernel density estimation (KDE). Figure 5 presents KDE-based probability density functions for three types of /ŋ/ realization, illustrating contrasts in their latitudinal distributions. Figures 2, 3, and 4 correspond to A-, B-, and C-type, respectively.

Although the A-type has a peak in higher latitudes, its distribution is sharply concentrated around a narrow band near 25°N and rapidly declines thereafter. Compared to A-type, B-type displays a narrower distribution centered closer to the equator and is far less represented in the northern high-latitude regions. In contrast, the C-type exhibits a broader and more sustained presence across the higher latitudes of the Northern Hemisphere. This suggest that, of the three types, the C-type maintains the most consistent density across northern high-latitude regions.

As observed, the restriction of /ŋ/ to syllable onset is found in a very small number of languages. Many languages do not prohibit /ŋ/ from appearing at syllable onset. This observation prompts a reassessment of the changes in the distribution of /ŋ/. For example, in Chinese and Korean, /ŋ/ has transitioned from occurring both at onset and in the coda to being realized only in the coda. If we rely only on a few well-known languages where velar nasals do not occur at syllable onset, this change might be misinterpreted as a move toward universality. However, the phonotactic constraint on velar nasals is generally absent, and so this change should be correctly interpreted as a move away from universality.

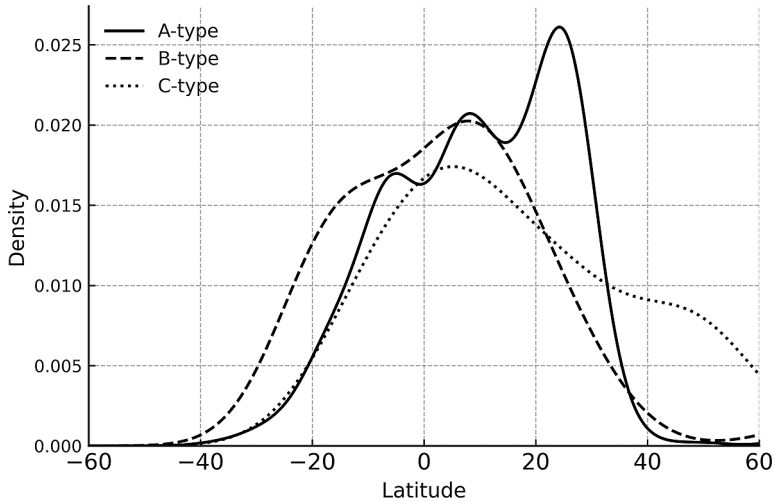

Figure 5. Latitudinal density distributions by three types of /ŋ/ realization

7. Conclusion

This study delves into velar nasals, focusing on their types, inventories, distinctions from other primary nasals, and distributions within syllables. Based on extensive language data, we aim to delineate various typological characteristics of velar nasals. The findings indicate that velar nasals are more marked and less prominent than other major nasals, such as bilabial and dental/alveolar nasals. Not only are the type diversity, language frequency, and percentage in the nasal inventory low for velar nasals, but their hierarchy in implicational relationships is also lower than those of other nasals. The distributional constraints within syllables are not as severe, and in many languages, the plain voiced velar nasal, /ŋ/, is not restricted to occurring either at onset or in the coda.

In previous works, velar nasals were often described very briefly. Detailed typological explanations in textbooks are scarce. In an effort to address this gap, this study aims to determine the comprehensive typological characteristics of velar nasals in many languages. We hope that this endeavor will expand and enrich understanding of velar nasals.

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【要　旨】

軟口蓋鼻音に関する類型論的研究

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本研究は，七つのマクロ地域にわたる 1,411 言語という大規模な言語資料に基づき，軟口蓋鼻音に関する四つの類型論的課題――その類型，音素目録，他の主要鼻音との差異，音節内における分布――を扱うものである。分析の結果，軟口蓋鼻音は，両唇鼻音や歯茎鼻音（歯鼻音を含む）といった他の主要鼻音と比較して，類型の多様性，言語的頻度，鼻音目録における比率のいずれもが低く，含意関係における階層性も他の鼻音より有標であることが明らかとなった。これは，軟口蓋鼻音が音響的に顕在性が低く，他の子音と混同されたり，他の子音に変化しやすいという事情に起因する。また，代表的な軟口蓋鼻音である /ŋ/ は，音節頭や音節末において実現されることに明確な制限はないことが，類型的に確認される。