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# EFFECTS OF PRECEDING VOWEL IN THE PERCEPTION OF THE ENGLISH NASAL CONSONANTS /m, n/ IN WORD-FINAL POSITION BY BRAZILIAN EFL LEARNERS

Denise Cristina Kluge (UFPR)

**ABSTRACT:** This article reviews and discusses some of the studies that investigated the effects of preceding vowel in the accurate identification and/or discrimination of the English nasal consonants /m/ and /n/ in word-final position by Brazilian learners of English (Kluge; Reis; Nobre-Oliveira; Bion, 2007; Kluge; Reis; Nobre-Oliveira; Bettoni-Techio, 2009; Kluge, 2010). The results of these studies show a tendency for the preceding high vowel to disfavor the accurate perception of the English nasal consonants and for the preceding low vowel to favor perception of this English contrast by Brazilian EFL learners, corroborating findings of previous studies such as Kurowski and Blumstein (1987, 1995).
**KEY-WORDS:** preceding vowel; nasal consonants; speech perception; phonological context

**RESUMO:** Este artigo revisa e discute alguns estudos que investigaram o efeito da vogal antecedente na identificação e/ou discriminação correta das consoantes nasais do inglês /m/ e /n/ em posição final de palavra por falante brasileiros aprendizes de inglês (Kluge; Reis; Nobre-Oliveira; Bion, 2007; Kluge; Reis; Nobre-Oliveira; Bettoni-Techio, 2009; Kluge, 2010). Os resultados desses estudos mostram uma tendência para a vogal antecedente alta desfavorecer a percepção correta das consoantes nasais inglesas e para a vogal antecedente baixa favorecer a percepção desse contraste do inglês por brasileiros aprendizes de inglês, corroborando resultados de estudos anteriores como os de Kurowski e Blumstein (1987, 1995).
**PALAVRAS-CHAVES:** vogal antecedente; consoantes nasais; percepção de fala; contexto fonológico

## 1. Introduction

The literature has shown that phonological context, especially preceding vowel, does affect the perception of English nasal consonants by either native or nonnative speakers of English (SHARF; OSTREICHER, 1973; KUROWSKI; BLUMSTEIN, 1984; REPP, 1996; ZEE, 1981, CITED IN KUROWSKI; BLUMSTEIN, 1995, P. 199; KLUGE; REIS; NOBRE-OLIVEIRA; BION, 2007; KLUGE; REIS; NOBRE-OLIVEIRA; BETTONI-TECHIO, 2009; KLUGE, 2010).

According to Lambacher (1995), nasal sounds are found in most languages of the world and the most common type of nasals are the bilabial /m/ and the alveolar /n/. Nasal consonants are similar to oral stop consonants in that both are produced with an obstruction somewhere within the oral cavity. However, nasal sounds differ as they are produced with the entire vocal tract, including both the nasal cavity and nasopharynx. Moreover, there is no interruption of airflow through the nasal cavity, unlike the obstruction of the nasal passage that is characteristic of oral stop consonants. As described by Stevens (1997) "a nasal consonant is produced by making a complete closure with one of the articulators, while maintaining an open velopharyngeal port" (STEVENS, 1997, p. 486). In nasal sounds the velum is lowered, allowing air to escape through the nose; whereas in nonnasal sounds the velum is raised, allowing the air to escape only through the mouth (GIEGERICH, 1992; PICKET, 1998; KENT; READ, 1992).

There are several acoustic consequences of opening the nasal cavity in the production of a nasal consonant which contribute to the acoustic complexity of nasal consonants (LIEBERMAN; BLUMSTEIN, 1988; KUROWSKI; BLUMSTEIN, 1995, KENT; READ, 1992). One of them is the nasal murmur which corresponds to the closure phase of the oral tract during the production of the nasal consonants (HARRINGTON; CASSIDY, 1999). Fujimura (1962) describes the nasal murmur as "the sound produced with a complete closure at a point in the oral cavity, and with an appreciable amount of coupling of nasal passages to the vocal tract" (FUJIMURA, 1962, p. 1865). This murmur must occur in the closure interval preceding the consonant release and it is characterized acoustically by a low-frequency spectral prominence around 250 Hz and lower amplitude peaks above 700Hz (FUJIMURA, 1962; KUROWSKI; BLUMSTEIN, 1995; LIEBERMAN; BLUMSTEIN, 1988). This murmur may be very short in duration, as little as two glottal pulses (FUJIMURA, 1962).

Ladefoged (2005, 2006) draws attention to a clear characteristic of the nasal consonants: an abrupt change in the spectrogram at the time of the formation of the articulatory closure when the lips come together for /m/ or when the tongue touches the roof of the mouth for /n/. He also points out that after this closure there is less amplitude in the nasal consonant itself.

Another acoustic consequence which characterizes nasal consonants, as well as nasalized vowels, is the presence of antiformants (antiresonances) or zeros as well as formants (FUJIMURA; ERI-

CKSON, 1997; KUROWSKI; BLUMSTEIN, 1995; JOHNSON, 2003). The articulation of nasal sounds creates antiresonances within the vocal tract. These antiresonances or antiformants are frequency regions in which the amplitudes of the source signal are attenuated because the nasal cavities absorb energy from the sound wave. The effects of these antiformants are more marked in nasal consonants than in nasal or nasalized vowels because consonants are articulated with a complete occlusion of the oral cavity.

Another aspect, mentioned by Kurowski and Blumstein (1995), that also contributes to the acoustic complexity of nasal consonants is variation in the anatomical structure of the nasal cavities from speaker to speaker, which increases the degree of interspeaker variability. Therefore, it may be more difficult to identify consistent acoustic parameters and frequencies in nasal consonants that can be generalized across speakers (GUBTYNOWICZ; LEGUENNAC; MERCIER, 1985, cited in KUROWSKI; BLUMSTEIN, 1995, p. 199).

Bearing these acoustic complexities of nasal consonants in mind, this article presents and briefly discusses: (a) the processes of nasalization in both English and Brazilian Portuguese (BP), especially in word-final position; (b) some studies on perception of nasal consonants as regards preceding vowel by native speakers of English; and (c) studies on the perception of nasal consonants by Brazilian learners of English.

## 2. Nasalization in English and Brazilian Portuguese

In English, the nasal consonants /m/ and /n/ in word-final position are fully pronounced (O'CONNOR, 1992), with different places of articulation (FUJIMURA; ERICKSON, 1997). In fact, these nasal consonants are phonologically distinctive in word-final position, contrasting in minimal pairs such as *cam-can*. As stated by O'Connor (1992), the English nasal consonant /m/ in word-final position is realized by lowering the soft palate and blocking the mouth by closing the lips. As for the realization of /n/, the mouth is blocked by pressing the tip of the tongue against the alveolar ridge, and the sides of the tongue against the sides of the palate. According to O'Connor, the pronunciation of neither of the sounds should cause much difficulty to most speakers, however, according to the author, speakers of some languages, such as Portuguese, may have difficulty pronouncing these nasal consonants in word-final position. O'Connor (1992) explains the processes done by some speakers in which the nasal consonant becomes a nasalized vowel as "instead of making a firm closure with the lips or tongue tip so that all the breath goes through the nose, they may only lower the soft palate and *not* make a closure, so that some of the breath goes through the nose but the remainder goes through the mouth" (p. 65).

According to the literature, the degree of nasalization differs among languages, from subtle as in English (GIEGERICH, 1992; HAMMOND, 1999; LADEFOGED, 2006) to strong as in BP (OLIVEIRA; CRISTÓFARO-SILVA 2005). It is important to state that although vowel nasalization can occur in English, there are no nasal vowels in this inventory (GIEGERICH, 1992), and nasalization of the vowel does not distinguish the meaning of English words (LADEFOGED, 2005), thus vowel nasalization is not a distinctive feature. In BP, nasalization is quite an issue and has motivated different explanations and theories, but, in general, it is assumed that: (a) phonetically, the nasal consonants /m/ and /n/ are not fully realized after a vowel in word-final position and sometimes not realized at all; and (b) the vowel assimilates nasalization from the following nasal consonant (CRISTÓFARO SILVA, 1999; MATEUS; D'ANDRADE, 2000; CÂMARA JR., 1971; KLUGE *et al*., 2009; KLUGE, 2010). The differences regarding the pronunciation of word-final nasals /m/ and /n/ in English and in BP are extremely relevant to understand the difficulties that Brazilians learners of English may have in the accurate identification of English word-final nasals.

## 3. Studies on perception of English nasal consonants as regards vowel context by native speakers of English

With reference to preceding phonological context, Kurowski and Blumstein (1995) point out that only few studies investigated the influence of vowel context on the perception of nasal consonants regarding place of articulation either in syllable-initial (SHARF; OSTREICHER, 1973; KUROWSKI; BLUMSTEIN, 1984; REPP, 1996) or syllable-final position (ZEE, 1981, cited in KUROWSKI; BLUMSTEIN, 1995, p. 199) by native speakers of English.

Sharf and Ostreicher (1973) investigated the perceptual effects of forward and backward coarticulation across syllable boundaries by 37 female American listeners. As for the identification of the bilabial and alveolar nasal consonants followed by a vowel, either /i/ or /u/, the results showed that /m/ was significantly more identified before /u/ than before /i/, whereas /n/ was significantly more often identified before /i/ than before /u/.

Kurowski and Blumstein (1984), investigating the role of the nasal murmur and the formant transitions in the perception of place of articulation of the English nasal consonants, also reported results for the influence of vowel context. Ten native speakers of English took a forced-choice identification test in order to indentify the nasal consonants /m/ and /n/ followed by one of the vowels /i, e, a, o, u/. The results regarding vowel context showed that it was more difficult for the participants to identify both nasal consonants before /i/ than before the other vowels /e, a, o, u/ in the condition containing both murmur and transition information of the nasal consonants.

Repp (1986) investigated the contribution of the nasal murmur and the vocalic formant transitions to perception of English /m/ and /n/ in syllable-initial position followed by /i, a, u/. The participants of this study were ten native speakers of American English, one native speaker of Russian and one of Chinese who were fluent in English. According to the researcher, the results of the nonnative speakers did not differ systematically from those of the native speakers. Regarding vowel context, results showed that, in general, it was more difficult for the participants to identify the nasal consonants before /i/ than before /a/ and /u/, corroborating the results of Kurowski and Blumstein (1984).

Zee (1981, cited in KUROWSKI; BLUMSTEIN, 1995, p. 199) investigated the effect of vowel quality on the perception of post-vocalic nasal consonants (labials, alveolars and velars) in white noise (i.e., noise within a wide range of random frequencies of uniform intensity, inserted to make the task more difficult) by native speakers of English. The results showed that labials were often incorrectly identified as alveolars after the front vowels /i/ and /e/, and velar nasals tended to be perceived as alveolars after the high front vowel /i/.

As reported by Kurowski and Blumstein (1995), the same vowel context effect for the identification of bilabials in the environment of /i/ and /i, e/ found in the studies reviewed above were also found with other consonant classes such as the stop consonants (KEWLEY-PORT, 1983, cited in KUROWSKI; BLUMSTEIN, 1995, P. 199, BLUMSTEIN; STEVENS, 1980).

Regarding perception of English nasal consonants by nonnative speakers of English, few studies have been conducted, to the best of my knowledge. Aoyama (2003) investigated the perception of syllable-initial and syllable-final English nasals by Korean and Japanese listeners; however, she did not investigate the effect of vowel context. Kluge *et al.* (2007), Kluge *et al.* (2009) and Kluge (2010) investigated the perception of word-final English nasals by Brazilian learners of English as well as the effect of preceding vowel. These studies will be presented and discussed in the next section.

## 4. Studies on perception of English nasal consonants as regards vowel context by Brazilian learners of English

Kluge *et al.* (2007) investigated the discriminations and identification of word-final nasals /m/ and /n/ by twenty pre-intermediate Brazilian learners of English. As a reference of comparison, a group of three native speakers of American English, who had lived in Brazil for an average of nine months by the time of data collection, also took the perception tests. Perception was assessed through a Categorial Discrimination Test (CDT), which was adapted from Flege, Munro & Fox (1994), and a Native-like versus Nonnative-like Identification Test in which the participants had to indicate which of the two pronunciations they heard was more native-like than the other, or whether either the two or neither

of them was native-like. In order to investigate the influence of preceding vowels (/ɪ, æ, oʊ, eɪ, ʌ/), there were five minimal pairs contrasting the word-final nasal consonant in each perception test. In the CDT the minimal pairs were: *Tim-tin, cam-can, tome-tone, came-cane* and *bum-bun*. Although the participants did not see the written words (as they just listen to the words in the trials), the fact that the minimal pairs *tome-tone* and *came-cane* are written with the grapheme "e" may have an influence in the perception of the Brazilian learners of English of this study whenever these participants believe the grapheme "e" in word-final position has to be pronounced in English. Thus, in order to avoid a spelling effect for the Native-like versus Nonnative-like Identification Test, none of the target nasals in word-final position were followed by the grapheme "e". Therefore, the minimal pairs for the identification test were: *Tim-tin, cam-can, loam-loan, maim-main* and *bum-bun*.

The results revealed that the preceding vowel of the study (/ɪ, æ, oʊ, eɪ, ʌ/) seemed to influence the accurate perception of the target nasals /m/ and /n/ by the Brazilian learners and the native speakers of American of English. Both groups seemed to have difficulties, although to different degrees, in either discriminating or identifying the target nasals in the context of high vowels, whereas low vowels seemed to favor the accurate perception of English coda nasals. The preceding vowels which most disfavored the accurate perception of the English word-final nasals by the Brazilian learners were /ɪ/ in the CDT, and /eɪ/ in the Native-like versus Nonnative-like Identification Test. In fact, these same vowels also influenced the accurate perception of the American speakers, since the preceding vowel /eɪ/ most disfavored perception in both perception tests, and /ɪ/ also hindered discrimination in the CDT. The fact that both native and non-native participants obtained rather low scores in the context of the same preceding high vowels provides evidence that this variable influences the perceptual performance of the nasals /m/ and /n/ in word-final position. The results also showed both nasal consonants were more accurately perceived by the Brazilians when the preceding vowel was /ʌ/: 55% in the CDT, and 58.75% of the items in the Native-like versus Nonnative-like Identification Test. Moreover, results showed that the preceding vowel /æ/ yielded the same difficulty in both perception tests, that is, 49.37% of accurate responses. Although results indicated that the high vowels seemed to disfavor the accurate discrimination of the coda nasals by the Brazilian learners and the native speakers, corroborating the results of Sharf and Ostreicher (1973), there was no statistical analysis to confirm the tendency of this study.

In another study, Kluge *et al.* (2009) investigated the identification of the word-final nasals /m/ and /n/ by ten intermediate Brazilian learners of English assessed by means of a Three-condition Identification Test with and without visual cues. In this test, there were six monosyllabic CVC words with either /m/ or /n/ in word-final position with three different preceding vowels (high /ɪ/, mid /ɛ/, low / æ /): *tim-tin, gem-gen, cam-can*. In order to avoid a spelling effect, none of words chosen for the corpus had the target nasals in word-final position followed by "e". The stimuli were produced by a

male native speaker of English and were presented in three different conditions: (a) *Audio only* (A), in which the participants could only hear the realization of a word; (b) *Audio/Video* (AV), in which the participants could hear and see the realization of a word; and (c) *Video only* (V), in which the participants could only see the realization of a word. The participants were asked to indicate which of the two nasal consonants they heard and/or saw. There were two blocks of 18 items per condition; giving a total of 108 tokens (18 items x 2 blocks x 3 conditions) per participant. Thus, each was repeated three times in each block.

Results revealed that /m/ was less frequently identified in the context of the preceding high vowel /ɪ/. The Friedman statistical test showed a significant effect for previous vowel followed by /m/ ($\chi^2$ (2, N=10) = 9.267, p = .01), thus Wilcoxon tests were run in order to verify whether the differences between the pairs of preceding vowels were significant. The tests showed significant differences for the pairs: high vowel versus mid vowel (Z = -2.536, p = .011); and high vowel versus low vowel (Z = -2.047, p= .041). The results thus indicated that a preceding high vowel inhibited accurate identification of syllable-final /m/, corroborating previous findings (KUROWSKI; BLUMSTEIN, 1987, 1995; KLUGE *et al.*, 2007).

As regards /n/, results showed that the alveolar nasal was more accurately identified in the context of the low vowel /æ/. The Friedman statistical test showed an effect of the preceding vowel on the identification of /n/ ($\chi^2$ (2, N=10) = 9.455, p = 0.009), and Wilcoxon tests yielded significant results for the pairs: high vowel versus low vowel (Z = -2.198, p = .028) and (c) low vowel versus mid vowel (Z = -2.552, p= .011). The results thus indicated that a preceding low vowel favored accurate identification of syllable-final /n/. While they corroborate those of Kluge *et al.* (2007), as hypothesized, this effect of a low previous vowel was not found in the case of /m/.

Due to the limited number of tokens, the authors analyzed this variable considering all three conditions tested (A, AV and V). Bearing this limitation in mind, Kluge (2010) conducted another study, based on the findings of Kluge *et al.* (2009) in order to further investigate the effect of preceding vowel in each of the three conditions tested. Kluge (2010) investigated the identification of the nasals /m/ and /n/ in word-final position by 42 Brazilian intermediate EFL learners: 21 men ranging in age from 18 to 59 years (mean = 24.2 years) and 21 women ranging in age from 18 to 27 years (mean = 20.7 years). A group of ten Americans: five men ranging from 32 to 63 years (mean = 44.2 years) and five women ranging in age from 27 to 68 years (mean = 45.6. years) whose data were used as a reference for comparison. As in Kluge *et al.* (2009), perception was assessed by means of a Three-condition Identification Test, which contrasted the presence and/or absence of visual cues in the identification of /m/ and /n/ through three types of stimuli presentation: *Audio/Video* (AV), *Video only* (V), and *Audio*

*only* (A). The effect of preceding vowels (high /ɪ/, mid /ɛ/, low /æ/) on the identification of the target consonants was controlled through the use of the six words *Tim-tin, gem-gen, and cam-can* produced by a male native speaker of English who was video recorded in a soundproof room.

The test taken by the participants consisted of 48 items (6 words x 8 repetitions) for each of the three conditions totaling 144 items (48 items x 3 conditions) per participant. The test was conducted individually and the order of the items of each condition was randomized for each participant so as to minimize ordering effect. Differently from Kluge *et al.*'s (2009) study which analyzed the effect of preceding vowel considering all three conditions tested, Kluge (2010) investigated this variable in each of the three conditions.

In general, results showed that the accurate identification of /m/ increased by context from the high preceding vowel to the low vowel to the mid vowel in all of the three conditions tested. The Friedman test showed that the differences were significant for the A ($\chi^2$ (2, N = 42) = 25.491, p = .000) and for the AV conditions ($\chi^2$ (2, N = 42) = 22.327, p = .000), but not for the V condition ($\chi^2$ (2, N = 42) = 3.561, p = .169). Wilcoxon post hoc tests yielded significance between all three pairs in the A only condition: /ɪ/ versus /ɛ/ (Z = -4.003, p = .000) and versus /æ/ (Z = -2.612, p = .009), and /ɛ/ versus /æ/ (Z = -3.414, p = .016). In the AV condition, the Wilcoxon test yielded significance between /ɪ/ versus /ɛ/ (Z = -3.442, p = .001) and versus /æ/ (Z = -2.854, p = .004). Thus, the high preceding vowel disfavored the accurate identification of the word-final /m/ by the Brazilians (KUROWSKI; BLUMSTEIN, 1995; KLUGE *et al.*, 2007; KLUGE *et al.*, 2009) in both the A and AV conditions, but not in the V condition. The vowel-context effect was stronger in the A condition, where both the high and low vowels disfavored accurate identification of /m/. Besides, the preceding mid vowel favored the accurate identification of /m/ in the A and AV conditions. Results of this study may also indicate that the vowel effect is valid only for auditory perception as it was only found in the A and AV conditions.

As regards the effect of preceding vowel on the identification of /n/, results showed that, in general, the Brazilians obtained lower scores in the context of the preceding mid vowel /ɛ/ in all of the three conditions tested. Similar to the vowel effect for /m/, the Friedman tests yielded significant differences for both the A condition ($\chi^2$ (2, N = 42) = 18.673, p = .000) and the AV condition ($\chi^2$ (2, N = 42) = 6.080, p = .048), but not for the V condition ($\chi^2$ (2, N = 42) = 4.200, p = .122). The Wilcoxon post hoc tests showed this significance to be only between /ɛ/ versus /ɪ/ – yielding (Z = -3.719, p = .000) in the A condition and (Z = -2.050, p = .040) in the AV condition – and between /ɛ/ versus /æ/ – yielding (Z = -3.529, p = .000) in the A and (Z = -2.047, p = .041) in the AV condition. No significance was found for /ɪ/ versus /æ/ in the A only condition (Z = -.324, p = .746) or in the AV condition (Z = -816, p = .414). Thus, these results indicate that the preceding mid vowel disfavored the accurate identification of the

word-final /n/ in the A and AV conditions by the Brazilian listeners of this study, and thus, did not totally corroborate Kluge *et al.* (2007), as the low preceding vowel favored accurate identification of the /n/ only compared to the mid vowel and not compared to the high vowel. Similar to the results concerning the bilabial consonant, these results indicated that the vowel effect found refers only to auditory perception.

Comparing the Brazilian and the American groups in relation to effect of preceding vowel in the Three-condition Identification test, the effects found for the Brazilian listeners in the A only and AV test conditions were not found for the American listeners in any condition. Thus, in this study, this effect appears to be relevant only for nonnative listeners.

## 5. Final remarks

In this article, some of the characteristics and the complexity of the English nasal consonants /m/ and /n/ were presented, and some of the studies carried out to in investigate the effect of preceding vowel in the perception of English nasal consonants by native speakers of English were reported. This article also reviewed and discussed the only three studies that, to the best of my knowledge, investigated the effect preceding vowel in the accurate identification and/or discrimination of English nasal consonants in syllable-final position by Brazilian learners of English. In general, the results of these studies showed that phonological context does affect the accurate perception of the target nasals, as suggested by the literature, either by native speakers or nonnative speakers of English (SHARF; OSTREICHER, 1973; KUROWSKI; BLUMSTEIN, 1984; REPP, 1996; ZEE, 1981, cited in KUROWSKI; BLUMSTEIN, 1995, P. 199; KLUGE, 2004, 2007).

Studies considering Brazilian/English interphonology are very important to contribute to the improvement of pronunciation teaching and the development of pronunciation/listening materials concerning the BP speakers' specific difficulties concerning English learning. The findings of the studies reviewed lead to some pedagogical implications, as they indicate Brazilians speakers' difficulties regarding the perception of English word-final nasals /m/ and /n/, for example. Thus, if language teachers become aware of which variables may favor/disfavor the accurate identification of those nasal consonants, they can help their learners to improve their L2 perception. Thus, if English teachers become aware of which preceding vowels may favor/disfavor the accurate identification of the English nasals /m/ and /n/, they may better help their learners to improve their identification by presenting and practicing those consonants in the context of each preceding vowel, starting by the vowels that favored accurate perception, for instance.

As suggestions for further research, future studies could investigate the identification of word-final nasals in the context of other preceding vowels in different identification/discrimination tests regarding audio and video input.

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