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A PHONETIC ANALYSIS OF BILABIALIZATION IN ENGLISH AND SLOVAK


Note:
Due to a technical mishap concerning IPA fonts, the phonetic symbols in the original printed version of this article do not show correctly. In other words, the paper in its original paper form is a mess. Unfortunately, this is not an isolated incident. In this pdf version all IPA symbols show correctly.
A Phonetic Analysis of Bilabialization in English and Slovak

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The paper is concerned with the qualitative phonetic analysis of bilabialization in English and Slovak. A corpus of English and Slovak spoken texts (of a particular genre) is analyzed by means of articulatory and acoustic techniques in search of progressive and regressive bilabializations. The mechanics of this type of assimilation is studied and explained by means of spatial constellations of articulators, temporal phasing of articulatory gestures, and the interplay of spectrographic parameters. It has been determined that there is a greater tendency to bilabialization in English than in Slovak (in the selected genre).

1. Introduction

Bilabialization is a type of assimilation. In general, assimilation gives rise to contextual variability of speech sounds, which is caused by the influence of one sound upon another. It is usually defined as a process of replacing one sound (or changing some properties of a sound) under the influence of another sound in its vicinity. Assimilation has also been characterized as an adjustment of speech sounds to their environment (cf. Malmberg 1963: 60; Abercrombie 1967: 133–134; Jones 1972: 217–218; Kráľ 1988: 111; Kráľ – Sabol 1989: 150; Farnetani 1999: 376; Roca – Johnson 1999: 34, inter alia).

The term bilabialization is not an officially accepted term in phonetics, and, as far as I know, it has only been used once in the phonetic literature (Lira 1976: 15). I will use it here as a general term for all assimilatory processes in which a sound without a bilabial closure assimilates to a sound with a bilabial closure (with or without the preservation of its original place of articulation). This term therefore differs from the term labialization in that it does not refer to lip-rounding or lip protrusion (cf. Kráľ 1965: 9; Benguerel – Cowan, 1974; Ladefoged 1975: 208; Bell-Berti – Harris 1982; Lubker – Gay 1982; Engwall 2000: 7–8; Bauer 2001: 266–267), and there must always be a bilabial closure, i.e. the resulting sound will possess the feature [+ bilabial]. There is no special diacritical superscript symbol used for this assimilatory process, nor do we need to devise any. This is because all bilabialized sounds are in fact regular bilabial occlusives which have their respective symbols in the IPA alphabet (see Handbook of the IPA, 1999). They are the following: [p], [b], and [m]. The symbols and diacritics used to transcribe bilabializations in this paper are based on the IPA (see Pavlík 2003: 260–272; 2004).

2. Articulatory mechanics of bilabialization

The articulatory mechanics of bilabialization (or any phonetic phenomenon, for that matter) can be analyzed by means of various methods and techniques. Traditionally, X-ray imaging, computed tomography, magnetic resonance imaging, and ultrasound are used to gather important articulatory data providing cross-sectional views of the tongue and other

![Diagram](image)

Fig. 1. Different degrees of bilabialization of the segment /n/ in the Slovak phrase on ma: (a) categorical alveolar articulation + categorical bilabial articulation, (b) non-categorical alveolar articulation + categorical bilabial articulation, (c) missing (elided) alveolar articulation + categorical bilabial articulation. (Sagittal sections are based on Dvončová – Jenča – Kráľ, 1969).

For example, the sagittal views of the vocal apparatus in Fig. 1 show the various possible configurations of the individual articulators during the process of bilabialization. Section (a) is a combination of two articulatory positions (gestures) – the tongue tip makes contact with the alveolar region in the production of [n], but, at the same time, the lips are prepared for the production of the following [m]. The two articulations, alveolar and bilabial, are produced simultaneously (they are coproduced). Section (b) shows a combination of a non-categorical alveolar articulation and a categorical bilabial articulation of the phoneme /n/. Finally, in the section (c) we can only detect the bilabial articulation and no alveolar articulation – the sound [n] has assimilated to [m].

Another technique that can capture the articulatory mechanics of bilabialization is the visualization of the articulatory processes by means of gestural scores. This technique has been developed as a descriptive tool within the framework of Articulatory Phonology which works with the so-called articulatory gestures. This theory of speech production has been trying to provide an alternative solution to the dichotomy between invariant discrete timeless phonological entities and the variant non-discrete spatio-temporal physical speech continuum (Browman – Goldstein, 1989, 1990, 1992, 2000; Byrd, 1992, 1996, 2003; Fowler – Saltzman, 1993; Byrd – Saltzman, 2002; Goldstein – Fowler, 2003, *inter alia*). In Articulatory Phonology, the basic units of phonological contrast are gestures.

For instance, within this theory, bilabialization can be said to occur when a bilabial closure gesture is produced within the temporal frame of a particular segment (originally) without a bilabial gesture. For example, when the /n/ is followed by /p/, as in the English phrase *ten pens*, the bilabial closure gesture of /p/ is initiated already during the production of the alveolar closure gesture for /n/. This results in the bilabialization of the /n/ segment.
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Fig. 2. A gestural score of the phrase *ten pens* with a bilabialized consonant */n/*. The bilabial closure gesture of */p/* is coproduced with the alveolar closure gesture of */n/*. (VEL = velum, TB = tongue body, TT = tongue tip, GLO = glottis).

When the bilabial gesture of */p/* begins during the production stage of the alveolar gesture for */n/*, the two gestures may overlap – they may be coproduced, i.e. produced simultaneously. The result of such a coproduction is a segment with two closures – alveolar and bilabial. This can be expressed by means of IPA symbols as double articulation – [ɯm]. Often, the alveolar closure gesture is decreased in magnitude – [ɯm], and it can also be completely elided, leaving only the bilabial closure gesture. In such cases, segment */n/* changes into segment */m/*.

A distinction must be made at this point between articulatory, acoustic, and auditory assimilation. This is because there are many cases of bilabialization where, when double articulation occurs, we can identify articulatory changes in the assimilated segment, but acoustically and auditorily there are almost no detectable variations of quality. This can happen when, as evident from the example (a) in Fig 1, */n/* is followed by */m/* and a double articulation [ɯm] is produced. In this case, the vocal tract stretches only as far as the alveolar closure for */n/*, so there is no labial cavity (which exists during the production of */m/*) that would change the resonating characteristics of */n/*. Put differently, in such a case there is usually no audible bilabialization – such a coproduced segment is likely to sound as */n/*.

Providing the gestures are not elided or reduced in magnitude, the temporal coordination of the individual gestures (the intergestural phasing) may vary to produce different gestural constellations in time, as we can see in the following figure.

Fig. 3 shows four different cases of temporal intergestural phasing occurring during bilabialization. The term *closure X* refers to any English or Slovak non-bilabial occlusion of plosives or nasals, such as */k/*, */t/*, */n/*, */c/*, etc. In (a) the closure X is followed in time by the
second (bilabial) closure which is then followed by the release of the closure X which, in turn, precedes the release of the bilabial closure. In (b) the closure X starts before the bilabial closure, but, unlike the previous case, both closures are released simultaneously. The third scenario, as shown in (c), involves two temporally simultaneous closures followed by two releases of which the top one occurs earlier than the bottom (bilabial) one. Finally, there is one more possibility as presented in (d), where both closures start and finish simultaneously, that is, their overlap is complete.

When closure X is reduced in magnitude, and this happens very frequently, the assimilation is usually acoustically auditorily detectable, and, over time, such reduced gestures may be elided completely, especially within the word, and these elisions may become coded at the deeper phonological level (see Bybee 2001: 20–21, 29–30; Taylor 2002: 307–308).

As we can see, bilabialization is not, or may not be, a discrete ‘either-or’ binary process, but there are usually different temporal and spatial constellations of the gestures involved. This is what the traditional phonology usually disregards and discards as non-distinctive detail. Such different phasing parameters, however, may give the receiver information about the speaker’s social class, tempo, style of speech, etc., and there may be some regular and systematic patterns found for these individual spatio-temporal constellations. This is why it is unwise to discard such phonetic details as unimportant and unnecessary.

3. Acoustic correlates of bilabialization

Let us now turn to the description of the main acoustic correlates of bilabialization. As far as vowels are concerned, their bilabialization occurs when they are preceded or followed by bilabial sounds. This causes typical formant transition patterns which we can see in the following spectrograms.

![Fig. 4. Spectrograms of the vowel formant transitions into and out of the bilabial consonant /b/ in nonsense syllables pronounced by the author.](image-url)
It is evident from the spectrograms in Fig. 4 that the main characteristic feature of the bilabialization of vowels is the presence of minus formant transitions in most vowels (Fry 1979: 138–140). The exception are the vowels [ɛ] and [ʊ], whose F3 appears to be steady rather than falling. Despite the fact that all of these vowels are acoustically bilabialized, mainly towards their offset stage of production, such vowels are not normally perceived as bilabialized, i.e. the listeners are usually not aware of any assimilation in this case.

As for the English and Slovak consonants, I will consider here those cases of bilabialization, where either both closure gestures are present in full magnitude (one extreme) or the first closure gesture is completely elided and the first segment thus changes into a different (bilabial) sound (the other extreme). The different temporal characteristics of the gestural phasing (see Fig. 3) are not indicated.

The following spectrograms are a small qualitative sample of some of the consonant bilabializations that occur in English and Slovak spoken texts.

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**Fig. 5.** Spectrogram of the phrase *beset by* with a bilabialized /t/ (speaker A.Y. – male, BBC World, newsreading).

The word-final /t/ in the phrase *beset by* in Fig. 5 is bilabialized (and glottalized) into [p̪], i.e. the alveolar gesture of /t/ is elided completely. This is evident from the minus transition of F2 of the preceding [ž], which indicates that the following stop is bilabial (cf. Fry 1979: 138–140; Kráľ–Sabol 1989: 176; Clark–Yallo 1995: 283–284).

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**Fig. 6.** Spectrogram of the phrase *happened at* (speaker N.G. – male, BBC World, newsreading).

An example of progressive bilabialization is given in Fig. 6, where the syllabic [n] in *happened* is assimilated into a syllabic [m] under the influence of the preceding /p/. In other words, the bilabial closure gesture for /p/ is still active during the production of the following
/n/, the alveolar gesture of which is elided completely. /p/ is released nasally – [pʰ] – and no acoustically measurable release burst is detectable in the spectrogram.

Fig. 7. Spectrogram of the phrase one point six (speaker N.G. – male, BBC World, newsreading).

Fig. 7 shows the bilabialization of /n/ into /m/. The alveolar gesture of the final /n/ of one is elided and coproduced with the bilabial closure gesture of the following /p/. The F2 of the preceding vowel [e] has a minus transition at the offset stage which indicates that the following sound is bilabial.

Fig. 8. Spectrogram of the phrase taking part (speaker C.B. – female, BBC Radio, newsreading).

The bilabialization of the word-final /ŋ/ in the word taking is shown in Fig. 8. The velar closure gesture of the nasal consonant is elided and it is replaced by the bilabial closure gesture of the following /p/. The F2 of the preceding vowel /i/ has a minus transition at the offset stage.

Fig. 9. Spectrogram of the phrase Bažant Pohoda (speaker V. S. – male, STV, newsreading).
The above spectrogram shows the complete phonetic elision of the sound [ŋ] and further reduction (elision) of the alveolar closure gesture of the segment /n/ in the Slovak word Bažant. The elided /n/ segment is overlapped with the bilabial closure of the following /p/, resulting in the production of the segment [m]. This can be seen in the F2 of the preceding vowel [y] – it has a minus transition. A similar situation is shown in Fig. 10 below.

Fig. 10. Spectrogram of the phrase napokon prehrali (speaker J. P. – male, STV, newsreading – sports), with the consonant /n/ bilabialized regressively to /m/ under the influence of the following /p/.

Fig. 11. Spectrogram of the word podpísalo (speaker I. Š. – male, Rádio Slovensko, newsreading).

Fig. 11 shows the alveolar closure gesture of the segment /t/ (assimilated in voicing) coproduced with the bilabial closure gesture of the following /p/ which results in a doubly articulated segment. The vocal tract extends only as far as the alveolar closure, and this is reflected also in the plus F2 transition of the preceding vowel /o/, which indicates that there is an alveolar closure present, i.e. the alveolar closure gesture is not elided. The release of the alveolar closure can be seen as a weak burst of energy (marked by a black oval) – the release is incomplete.
In Fig. 12 we see the bilabialization of the segment /c/. The palatoalveolar closure of /c/ and the bilabial closure /p/ are initiated simultaneously, and then the palatoalveolar closure is released while the bilabial closure is still maintained. The palatoalveolar release is therefore weak, and this is marked by a black oval both in the oscillogram and the spectrogram. Normally, the palatoalveolar plosion (accompanied by affrication) is longer and more prominent than any other type of plosion in Slovak.

The velar closure gesture of the segment /k/ in Fig. 13 is coproduced with the bilabial closure gesture of the following segment /p/ producing a doubly articulated segment [kp’]. The fact that the velar closure is not elided is evident from the plus F2 transition of the preceding vowel [v]. The release burst of /k/ is completely missing, whether acoustically or auditorily.
4. A comparison of English and Slovak bilabializations

The analysis of the individual cases of bilabializations and their comparison in English and Slovak has been made from a synchronic qualitative point of view. The particular occurrences of bilabializations have been analyzed acoustically and auditorily (and partly also articulatorily). They have been visualized by means of spectrograms, palatograms, extrapolated sagittal views, gestural scores, and segmental IPA transcription. The spoken texts used in the analysis have been collected from national TV and radio stations in Britain and Slovakia – the BBC, the STV, and Rádio Slovensko. The individual examples of bilabializations used in the paper have been selected from a sample of 13 English and 13 Slovak newsreaders. The selected texts have the following characteristics:

Spoken texts, read/prepared, were produced by educated monolingual middle-class speakers (males and females of different ages, without regional features) in formal style during the national TV/radio newsreading in the studio. Such sociolinguistically delimited linguistic variety approximates what is usually referred to as standard pronunciation, Received Pronunciation, or spisovná výslovnosť. The samples do not include pre-recorded and edited news segments of out-of-studio reporters. This means that the collected and analyzed texts are samples of live unedited studio broadcast which ensures the (relative) compatibility of the texts of the two different languages.

Based on the available literature concerning this phenomenon, where, however, the term bilabialization is not normally used (cf. Stanislav 1953: 268; Záborský 1975: 95; Kráľ 1976: 310; Lira 1976: 15; Lenhardt 1981: 24; Roach 1991: 124–126; Byrd, 1992; Gimson – Cruttenden 1994: 177, 258–260; Zsiga, 1994, inter alia), and combined with my qualitative analysis of English and Slovak spoken texts, it can be concluded that bilabialization in English and Slovak occurs in all contexts where a non-bilabial sound is followed by /p/, /b/, or /m/, i.e. intra-morphemically and inter-morphemically within the word, and also at word boundaries. Different types of sounds, however, may be bilabialized to different degrees, and some bilabializations may not be auditorily perceivable (although articulatorily and acoustically they are detectable). Attention here is focused mostly on those bilabializations which tend to be relatively prominent and detectable in the medial production stage of the assimilated sound. These auditory bilabializations are more often regressive than progressive. The only auditorily prominent progressive bilabialization, as far as I have been able to determine, occurs in English, and it is only found in the case of the sound /n/ assimilating to a syllabic /m/ under the influence of the preceding /p/ or /b/, e.g. happen [ˈhæpən], ribbon [ˈrɪbɒn]. These cases are well documented in phonetic literature (Brosnahan – Malmberg 1970: 133; O’Connor 1973: 146; Roach 1991: 81; Gimson – Cruttenden 1994: 260, inter alia).

The sample of the spectrograms presented above serves to document the existence of bilabializations (whether with single articulation or double articulation) that occur in the spoken texts I have analyzed. Nothing can be said at this point about the qualitative characteristics of this phenomenon or the contextual factors that influence its occurrence. Such research still needs to be carried out.

It was mentioned earlier that vowels show very weak auditory bilabialization, and they are therefore not included in the following analysis. Similarly, many consonants, e.g. /s/, /ʃ/, /θ/, /ð/, etc., effectively resist bilabialization. The tables below present simplified overviews of the main regressive (and two progressive) cases of consonant bilabialization in English and Slovak.
Bilabialization in English | Example
---|---
\([t] + [p] \text{ or } [b] \rightarrow [\text{tp}]\), \([\text{tp}]\), or \([p] + [p] \text{ or } [b]\) | a bit pale, a lot better
\([t] + [m] \rightarrow [\text{tp}]\), \([\text{tp}]\) or \([p] + [m]\) | not me
\([k] + [p] \text{ or } [b] \rightarrow [kp] + [p] \text{ or } [b]\) | weak point, thick bones
\([k] + [m] \rightarrow [kp] + [m]\) | sick mind
\([d] + [p] \text{ or } [b] \rightarrow [db] \text{ or } [b] + [p] \text{ or } [b]\) | red pen, good bye
\([d] + [m] \rightarrow [db] + [m]\) | bad man
\([g] + [p] \text{ or } [b] \rightarrow [gb] + [p] \text{ or } [b]\) | big problem, big boy
\([g] + [m] \rightarrow [gb] + [m]\) | big man
\([n] + [p], [b] \text{ or } [m] \rightarrow [nm] + [p], [b] \text{ or } [m]\) | ten pens, on board, in my
\([n] + [p], [b] \text{ or } [m] \rightarrow [nm] \text{ or } [m] + [p], [b] \text{ or } [m]\) | ping-pong, taking part
\([p] + [\text{̆}] \rightarrow [pm] \text{ or } [p]\) | happen
\([b] + [\text{̆}] \rightarrow [bm] + [m]\) | ribbon

Table 1. An analysis of regressive (and progressive) bilabialization in English

Bilabialization in Slovak | Example
---|---
\([t] + [p] \rightarrow [\text{tp}] + [p]\) | hlad prišiel
\([t] + [m] \rightarrow [\text{tp}] + [m]\) | potme
\([č] + [p] \rightarrow [\text{cp}] + [p]\) | choď priamo
\([k] + [p] \rightarrow [kp] + [p]\) | vlak piska
\([k] + [m] \rightarrow [kp] + [m]\) | rozkmitať
\([d] + [b] \rightarrow [db] + [b]\) | kliatba, hrad bol
\([d] + [m] \rightarrow [db] + [m]\) | striedmo, brat musel
\([ť] + [b] \rightarrow [ťb] + [b]\) | vedť by
\([ť] + [m] \rightarrow [ťb] + [m]\) | zobuť ma
\([g] + [b] \rightarrow [gb] + [b]\) | ak by
\([g] + [m] \rightarrow [gb] + [m]\) | tak ma, dogma
\([n] + [p], [b] \rightarrow [nm] \text{ or } [m] + [p], [b] \text{ or } [m]\) | zákon prijali, on bol
\([n] + [m] \rightarrow [nm] + [m]\) | on ma
\([ň] + [p], [b] \text{ or } [m] \rightarrow [ňm] \text{ or } [ň] + [p], [b] \text{ or } [m]\) | deň po, týždeň bude

Table 2. An analysis of regressive bilabialization in Slovak

The comparison of the two tables above reveals that, in general, there is greater tendency in English than in Slovak to completely elide the closure gesture of the first consonant. In Slovak this is possible (in the texts analyzed) only in the sequences of nasals plus a bilabial plosive. It must be pointed out, however, that such inter-word bilabializations of /n/ to /m/ appear to be rather rare in the genre analyzed (i.e. newsreading). In the codified Slovak pronunciation (Kráľ 1988: 155; 2005: 74), only intra-word bilabialization of /n/ followed by /p/ or /b/ is acceptable. The status of doubly articulated bilabialized segments has not been assessed by Slovak phoneticians yet.

In both languages, it would appear, the segments that are assimilated under the influence of the following (or preceding) bilabial consonant are plosives and nasals. However, due to sequential combinatoriality, there are in Slovak fewer possibilities of combinations...
from a phonotactic point of view. That is, sequences such as [t] + [b], [k] + [b], [d] + [p], etc. are not included in the above table, because only combinations of plosives that agree in voicing are normally possible in standard Slovak, although voicing assimilations were often non-categorical in the texts I have analyzed. It must also be pointed out that the quality of the individual English and Slovak segments in the sequences above is not identical, even though the symbols may look the same (I have used a narrow type of allophonic transcription only in terms of the place features of articulation). Finally, auditorily prominent progressive bilabialization which we can find in English does not exist in Slovak.

The bilabializations that are usually prominent auditorily (not just articulatorily and/or acoustically) have been highlighted. These bilabializations involve a complete reduction of the original lingual gesture magnitude, and such gesture is, articulatorily, acoustically, and auditorily, perceived as elided. Phonologically, it may still be present in the (higher) underlying structure, and its magnitude reduction can be specified by lower-level phonological/phonetic rules. The segments that can undergo such auditorily prominent bilabializations in the selected texts are /t/, /d/, /n/, and /ŋ/ in English, and /n/ in Slovak. The main difference between the two languages is, obviously, the number of such segments – four to one. Another thing to be noticed is the place of articulation characteristics of the segments – they are mostly alveolars, with the exception of the velar /ŋ/ in English, whose tendency to be categorically bilabialized appears to be lesser than the other segments’.

One last comment on the bilabialization of the Slovak /n/ to /m/ is needed. As I have stated, this case of bilabialization with the complete elision of the alveolar gesture is rather rare because I have collected only three tokens in a rather large corpus of spoken texts (over 2 hours of connected speech per each language). What is more, one of these tokens comes from a sports newreader. Although this lect has the same parameters as the reading of (evening) news (that is the reason I have included it in the analysis), it appears that in this variety there are more cases of place assimilations than in the reading of regular (evening) news. If this finding is supported by a quantitative analysis based on a larger sample, then one could hypothesize that the field (topic) variable may be responsible for the higher occurrence of assimilations (see Pavlík 2006: 179–180). It should also be noted that bilabialization seems to be more frequent in genres of informal style. However, no statistical data concerning this phenomenon in Slovak are available yet.

5. Conclusion

The assimilatory phenomenon of bilabialization can be characterized as a process in which a sound without a bilabial closure assimilates to a sound with a bilabial closure. It occurs both in English and Slovak, and the mechanisms underlying this process appear to be the same. Nevertheless, the degree and direction of bilabializations in the two languages are not the same. There is greater tendency in English than in Slovak to completely elide the closure gesture of the first (assimilating) consonant. The segments that are assimilated under the influence of the following (or preceding) bilabial consonant in both languages are plosives and nasals. Due to constraints of sequential combinatoriality and voicing assimilation, fewer possibilities of consonant combinations are available in Slovak in comparison to English. This contributes to fewer bilabializations in Slovak. From an auditory point of view, English has both progressive and regressive bilabializations, whereas Slovak exhibits only regressive bilabializations.
Súhrn

References