Hungarian neutral vowels: a microcomparison*

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Abstract

In Hungarian, stems containing only front unrounded (*neutral*) vowels fall into two groups: one group taking front suffixes, the other taking back suffixes in vowel harmony. The distinction is traditionally thought of as purely lexical. Beňuš and Gafos (2007) have recently challenged this position, claiming that there are significant articulatory differences between the vowels in the two groups.

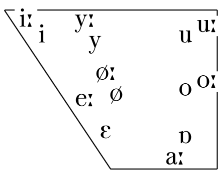
Neutral vowels also occur in vacillating stems. These typically contain one back vowel and one or more neutral vowels, and accept both front and back suffixes, with extensive inter- and intra-speaker variation. Based on Beňuš and Gafos's line of argument, the expectation is that vacillating stems will display a kind of phonetic realisation that is distinct from both harmonic and anti-harmonic stems.

We present the results of an ongoing acoustic study on the acoustics of neutral vowels, partly re-creating Beňuš and Gafos's conditions, but also including vacillating stems. To map the extent of individual and dialectal variation regarding vacillating stems, a grammaticality judgement test was also carried out on speakers of two dialects of Hungarian, crucially differing in the surface inventory of neutral vowels. We present our first findings about how this phonetic difference influences the phonological behaviour of vacillating stems.

1. Data and background[1]

1.1. Hungarian vowel harmony

The Hungarian[2] vowel system contains seven short and seven long vowels. While orthography might suggest that long vowels are straightforwardly paired up with the corresponding short vowel, some short-long pairs differ more in quality than others: notably <e> and <é> correspond to [ɛ] and [eː], respectively. The vowel system of Hungarian is presented in Table 1 below (cf. Siptár and Törkenczy 2000:51):



	front				back	
	[-round]		[+round]			
high	i	iː	y	yː	u	uː
mid		eː	ø	øː	o	oː
low	ɛ				ɒ	aː

Figure 1: The Hungarian vowel system

Hungarian has two harmony patterns: font/back harmony and rounding harmony; only the former will be dealt with in this paper. Front/back harmony in Hungarian is stem-controlled. Most suffixes have a

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[1] The following description is based on Hayes et al. (2009) and Szeredi (2012).

[2] 'Hungarian' refers to the standard (Budapest) dialect unless indicated otherwise.

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http://www.ub.uit.no/baser/nordlyd

front and a back allomorph: stems with only back vowels select the back suffix and stems with only front vowels select the front suffix, as illustrated in (1–2). In mixed stems, that is, stems that contain both front and back vowels, it is usually the last (rightmost) vowel of the stem that determines the frontness of the suffix vowel (3–4). The suffix attached in these examples is the dative, which alternates between the [nɒk] back and [nɛk] front allomorphs:

(1) *back stem:* hɒjoː 'ship' ~ hɒjoːnɒk, *hɒjoːnɛk

(2) *front stem:* tɛtøː 'roof' ~ tɛtøːnɛk, *tɛtøːnɒk

(3) *mixed back stem:* tɛrɒs 'terrace' ~ tɛrɒsnɒk, *tɛrɒsnɛk

(4) *mixed front stem:* ʃoføːr 'driver' ~ ʃoføːrnɛk, *ʃoføːrnɒk

The front unrounded vowels (/i/, /iː/, /ɛ/ and /eː/), also called *neutral vowels*, display a set of exceptional patterns with respect to vowel harmony: transparency, anti-harmony and vacillation.

The transparency of the front unrounded vowels means that these vowels seem to be invisible to harmony: if a stem-final neutral vowel is preceded by a back vowel, the suffix will be still back. This is illustrated by the following examples:

(5) *transparent Bi stem:* kotʃi 'car' ~ kotʃinɒk, *kotʃinɛk

(6) *transparent Biː stem:* fɒkiːr 'fakir' ~ fɒkiːrnɒk, *fɒkiːrnɛk

(7) *transparent Beː stem:* kaːveː 'coffee' ~ kaːveːnɒk, *kaːveːnɛk

(8) *transparent Bɛ stem:* mɒtɛk 'maths' ~ mɒtɛknɒk, *mɒtɛknɛk

Note that if there is more than one neutral vowel following the back vowel in a stem, then the suffix is more likely to to have a front vowel (termed the *Count Effect* by Hayes et al. 2009). The height of the neutral vowel also affects its transparency: lower neutral vowels are more likely to attract front suffix vowels (termed the *Height Effect* by Hayes et al. 2009). Section 1.3 elaborates on these data patterns.

1.2. Antiharmonicity

Most stems which contain only front unrounded (neutral) vowels take front suffixes, as illustrated in (9–11):

(9) *front i stem:* siːv 'heart' ~ siːvnɛk, *siːvnɒk

(10) *front eː stem:* eːv 'year' ~ eːvnɛk, *eːvnɒk

(11) *front ɛ stem:* hɛj 'place' ~ hɛjnɛk, *hɛjnɒk

However, certain stems with only neutral vowels take *back* suffixes. These stems will be labelled *antiharmonic* in this paper. Most antiharmonic stems are monosyllabic, as in (12–14), although there are disyllabic antiharmonic nouns (15–16), and more verbal stems which are formed with non-alternating derivative suffixes (17).

(12) *antiharmonic iː stem:* ɲiːl 'arrow' ~ ɲiːlnɒk, *ɲiːlnɛk

(13) *antiharmonic i stem:* fiŋg 'fart' ~ fiŋgnɒk, *fiŋgnɛk

(14) *antiharmonic eː stem:* tseːl 'target' ~ tseːlnɒk, *tseːlnɛk

(15) *antiharmonic NN stem:* dɛreːk 'waist' ~ dɛreːknɒk, *dɛreknɛk

(16) *vacillating NN stem:* feːrfi 'man' ~ feːrfinɒk or feːrfinɛk

(17) *antiharmonic verbal NN stem:* ʃimiːt 'smoothen' ~ ʃimiːtɒnɒk 'they smoothen', *ʃimiːtɛnɛk; constructed by affixing the causative -iːt to the adjectival Bi stem ʃimɒ 'smooth'

The Height Effect described in Hayes et al. (2009) applies for antiharmonicity as well. There are no antiharmonic stems with the low vowel [ɛ] in the language, and only a few with [eː], like (14) and (15). Antiharmonic stems with [i] and [iː] are more frequent, and it seems that stems with the long vowel and verbal stems are more likely to be antiharmonic. A quick survey using the web corpus Szószablya (Halácsy et al. 2004) shows that of the 23 verbal [i(ː)] stems, 18 (78.3%) take back, 5 (21.7%) take front suffixes, while of the 145 nominal [i(ː)] stems, 19 (13.1%) are antiharmonic, and 126 (86.9%) are harmonic.

The two sets of neutral vowels (that is, the ones in harmonic and the ones in antiharmonic stems) have impressionistically been assumed to have the same quality. Therefore, traditional analyses of the phenomenon always involved an underlying (lexical) distinction between these stems or stem vowels that is completely neutralised before phonetic interpretation (cf. Booij 1984, Clements 1976, Dienes 1997, Esztergár 1971, Hare 1990, van der Hulst 1985, Kontra and Ringen 1986 ff. Kornai 1987, Morén 2006, Ringen 1978 ff., Ringen and Vago 1998 ff., Vago 1976 ff., Zonneveld 1980, *inter alia*).

1.2.1. Phonetic correlates of transparency and antiharmonicity

This paper focuses on the hypothesis that there are phonetic correlates of antiharmonicity of the stem vowel. The expected difference between an [i(ː)] in an antiharmonic stem and in a harmonic stem is that in an antiharmonic stem one would expect a less peripheral, more retracted vowel.

This is a plausible hypothesis because in an antiharmonic stem, the vowel is more often flanked by back vowels, leading to coarticulation. It has been shown that in two vowels separated by consonants do have an articulatory and acoustic influence to each other (Öhman 1966). For example, the F2 formant transition between [ø] and the consonant in the utterance [øgɑ] shows movement towards a frequency characteristic to back vowel; whereas F2 is even raising in the utterance [øgy]. The extent of coarticulation for a given VCV sequence is language-specific, and has been proposed to be the phonetic grounding for vowel harmony (Beddor et al. 2002). In the case of Hungarian antiharmonicity, coarticulation of an antiharmonic [i(ː)] with the neighboring back vowels means that the retracted tongue body of the back vowels causes the tongue body to be less fronted for the [i(ː)] than in other environments or in isolation.

1.2.2. Articulatory effects

In their articulatory experiment, Beňuš and Gafos (2007) have reported a correlation between stem type and the backness of the neutral vowel: their study shows that neutral vowels in antiharmonic stems are articulated with a more retracted tongue body than the same vowel in a harmonic stem. For example, the tongue body during the vowel in antiharmonic stems like [viːv] 'he is fencing' and [iːr] 'he is writing' is more retracted than in corresponding antiharmonic minimal pairs like [iːv] 'bow' and [hiːr] 'news'. They have also found the same effect for the final vowels in suffixed transparent stems: the [iː] in [zɒfiːrbɒn] 'in sapphire' is more retracted than in [zɛfiːrbɛn] 'in zephyr'. The transparent stimuli were always suffixed, therefore the [iː] in these words were always flanked with back or front vowels in both sides, and the articulatory effect is easy to analyse by coarticulation, therefore results on these stimuli will be ignored below.

Beňuš and Gafos used ultrasound measurements and electromagnetic midsagittal articulometry (EMMA, Perkell et al. 1992, Stone 1997) to examine the articulatory characteristics of the vowels. In their EMMA study, 8 receivers were placed in a mid-sagittal plane, including two receivers on the tongue body and one on the tongue dorsum. Their stimuli were harmonic and antiharmonic monosyllabic words and trisyllabic suffixed transparent words embedded in the test sentence [ɒst mondom hoɟ X, eːʃ ɛliʃmeːtlɛm ɒst hoɟ X meːgɛtsːɛr] 'I said X, and I repeat X once again'. They collected 4 repetitions of 16 monosyllables (8 harmonic–antiharmonic pairs, 6 with [i(ː)] and 2 with [eː], 128 tokens in total) from two subjects, and 4 repetitions of 6 monosyllables (24 total) from a pilot test subject. Three tongue receivers were used in the analysis: the two on the tongue body and one on the tongue dorsum (for the pilot subject one on the tongue tip, one on the tongue body and one on the tongue dorsum). Ultrasound data were only analysed for one subject, who took part in the EMMA experiment as well.

The study found that in monosyllabic stems, one receiver out of three for one subject (using one-way ANOVA, F(1,124)=4.005, p=0.048 on the second receiver on the tongue body), and all three for the other (F(1,116)=6.94, p=0.01 for the tongue dorsum; F(1,116)=11.403, p<0.001 for the second receiver on the tongue body; F(1,116)=7.453, p=0.007 for the first receiver on the tongue body) were significantly more retracted in antiharmonic stems. For the pilot subject, the tongue dorsum receiver was more retracted for the antiharmonic stem 9 times out of 12 antiharmonic–harmonic pairs, but no statistical analysis was made to see whether this is significant. The ultrasound measurements made on one subject showed the same effect, although it did not come out as significant on an $\alpha = 0.05$ level (F(1,318)=2.915, p=0.089). As the monosyllabic stimuli were presented with no suffix, the differences in vowel backness cannot be attributed to coarticulation.

The most relevant claim of Beňuš and Gafos' study for the current paper is that front unrounded vowels in antiharmonic stems are more retracted than in harmonic stems, and "these difference must be part of the speakers' knowledge of these stems" (Beňuš and Gafos 2007:286). According to their analysis, the behaviour of Hungarian antiharmonic (and transparent) vowels might indicate that there is an underlying distinction between a retracted /i̠/ and a full /i/. This distinction might be based on any representational level, but it does not require a phonemic analysis, the main point is that the distinction between these two categories for a high front unrounded vowel is present in the lexicon.

If there is indeed a correspondence between the articulation of neutral vowels in harmonic and antiharmonic stems, and as Beňuš and Gafos (2007) suggest, this is also reflected in their grammar, the question arises if neutral vowels also display unique phonetic characteristics when they are found in another class of 'non-standardly harmonic' stems: vacillating stems.

1.3. Vacillating stems[3]

Vacillating stems typically contain a back vowel followed by one or more neutral vowels. The crucial phonological property of these stems is that the same stem can take both front *and* back suffixes, althought there is a considerable amount of inter- and intra-speaker variation. Examples of vacillating stems are shown in (18) below.

(18)	*haver*	[hɒvɛr]	'buddy'
	dzsungel	[d͡ʒungɛl]	'jungle'
	balhé	[bɒlhé]	'trouble'
	aszpirin	[ɒspirin]	'aspirin'
	martini	[mɒrtini]	'martini'

The work of Hayes et al. (2009) gives an insight on how transparency and vacillation work in Hungarian.[4] Based on a web search study (also cf. Hayes and Londe 2006) and in a wug test eperiment, they found that while neutral vowels are indeed transparent to harmony, their transparency is constrained by the Height Effect and the Count Effect.

The Height Effect refers to the pattern that the higher neutral vowels are more likely to be transparent than lower ones. Thus, while almost all monomorphemic stems with a final [i(ː)] preceded by a back vowel take back suffixes (with the exception of compounds, which are still transparent, as in (19)), stems with a final [eː] are more likely to allow front suffixes, as in (21). Stems with a final low [ɛ] are mostly vacillating — both suffixes are accepted, as in 22, although the preferences vary between speakers and stems.

(19) *front mixed Bi stem – only compounds:* rɒjs+film 'cartoon' ∼ rɒjs+filmnɛk, *rɒjs+filmnɒk

(20) *front mixed Beː stem – mostly compounds:* lɒg+beːr 'rent' ∼ lɒg+beːrnɛk, *lɒg+beːrnɒk

[3] We believe the term *vacillating stem* comes from Péter Siptár, but we have not been able to pinpoint its first written ocurrence.

[4] In their analysis, they only refer to front rounded vowels as front (F); they call front unrounded vowels neutral (N). Back vowels are abbreviated with a B.

(21) *vacillating Beː stem:* ɒteːn 'Athens' ∼ ɒteːnːɒk or ɒteːnːɛk

(22) *vacillating Bɛ stem:* fotɛl 'sofa' ∼ fotɛlnɒk or fotɛlnɛk

The Count Effect refers to the observation that more than one neutral vowel in the end of a stem will act as if these two vowels were being less transparent aggregately than individually. A stem ending in an [ɛ] preceded by another neutral vowel and a back vowel will take exclusively front suffixes (23), while a stem with back vowels and a single final [ɛ] usually vacillates as in (22). In the same way, while a stem with back vowels and a final [i(ː)] almost always take back suffixes (as in (5)), stems with back vowels ending in two [i(ː)] high front vowels are mostly vacillating:

(23) *front BNɛ stem:* lutsifɛr 'Lucifer' ∼ lutsifɛrnɛk, *lutsifɛrnɒk

(24) *vacillating Bii stem:* ɒspirin 'aspirin' ∼ ɒspirinːɒk or ɒspirinːɛk

The exact patterning of vacillating stems seems to be governed by analogical and morphological factors as well. In an analysis of the Hungarian Webcorpus, Kálmán et al. (2010) compared suffixed forms of vacillating stems with monomorphenic words of the same shape (e.g. CaCiCa vs. CaCi+Ca). They found a significant correlation: vacillating stems have a preference for choosing harmonic variants of suffixes so that the result is similar to monomorphemic words. In another study (Törkenczy et al. 2011), they have shown that the morphonological role of the suffix also determines whether a neutral vowel is transparent of triggers vacillation in following suffixes.

If we accept the suggestion of Beňuš and Gafos (2007) that there is a direct correlation between the phonetic characteristics of neutral vowels and their antiharmonic behaviour, then we also expect neutral vowels in vacillating stems to have a unique phonetic realisation.

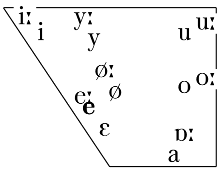
1.4. Dialectal comparison

To be able to distinguish between the effect of phonetics *vs.* phonological behaviour, we gathered data from two, phonetically minimally different dialects: Standard Hungarian, referred to here as the Budapest dialect, and a variety of Slovakian Hungarian, spoken in and around the town of Párkány (south-western Slovakia, Nitra county).

Párkány (officially *Štúrovo* in Slovak) is a small town of 10 851 inhabitants in Slovakia (Štatistický úrad Slovenskej Republiky [Statistical Office of the Slovak Republic] 2011). The town is only 42 kilometers northwest from Budapest and the majority of the inhabitants are Hungarian speakers. The town is near the Palóc dialect region (Kiss 2001), and speakers have preserved many archaic non-standard dialectal characteristics due to the separation of Párkány from the majority of the Hungarian-speaking community since 1920, when the town was awarded to Czechoslovakia. Since 2001, when a new bridge was built between Párkány and the Hungarian town of Esztergom, exposure to the standard language increased, and accelerated even more after the two countries were admitted to the European Union in 2004, and after 2008, when border control between the two countries was abolished due to the Schengen Agreement. Figure 2 shows the approximate locations of Budapest and Párkány.

The main difference between the vowel system of Standard Hungarian and the Párkány dialect is the presence of a short mid front unrounded vowel /e/, which has merged with /ɛ/ in the standard (see Figure 3, compared to Figure 1). The presence of this vowel is expected to have consequences in the behaviour of transparency/vacillation, but it is unlikely that it would alter the behaviour of antiharmonic stems with /i(ː)/. All stimuli for antiharmonicity are unquestionably antiharmonic in both dialects.

Figure 2: Approximate locations of Budapest and Párkány



	front				back	
	[-round]		[+round]			
high	i	iː	y	yː	u	uː
mid	**e**	eː	ø	øː	o	oː
low	ɛ				a	ɔː

Figure 3: The vowel system used in Párkány. The additional phoneme is highlighted.

2. Grammaticality judgement experiment

2.1. Methodology

The primary aim of this experiment was to determine which stems are vacillating for each subject — as discussed in section 1.3, there is a great deal of individual variation. In addition, we also tested for dialectal differences between Budapest and Párkány speakers.

2.1.1. Stimuli

The set of stimuli consisted of four vacillating stems, two front control stems and two back control stems for each neutral vowel (/i/, /iː/, /ɛ/ or /e/ and /eː/.),[5] yielding a total of 30 test words including vacillating stems and stable stems. In vacillating stems, orthographic <e> corresponds to /e/ in the Párkány dialect and to /ɛ/ in the Budapest dialect.

Given the large amount of variation involving vacillating stems, each test word's categorisation (vacillating, front or back) was confirmed using the Szószablya annotated corpus (Halácsy et al. 2004) and Google.

In choosing the stimuli, preference was given to string similarity, even at the expense of morphological differences. Table 1 shows examples of the test stimuli, with compounds in boldface.

[5]The exception to this was the vowel /eː/, where one back and one front control stem was used for the experiment detailed in this paper. This imbalance in the set of stimuli was amended in later experiments.

	vacillating	control F	control B
/i/	ɒspirin ‘aspirin’	**rɒjsfilm** ‘cartoon’	kotʃi ‘cart’
/iː/	objektiːv ‘objective’	selektiːv ‘selective’	ɒktiːv ‘active’
/ɛ/-/e/	hotɛl ‘hotel’	**moːdsɛr** ‘method’	mɒtɛk ‘maths’
/eː/	ɒteːn ‘Athens’	**lɒkbeːr** ‘rent’	kaːveː ‘coffee’

Table 1: Examples of stimuli for the decision experiment

2.1.2. *Presentation*

The test words were presented in suffixed forms (only suffixes with alternating [ɛ]∼[ɒ] and [eː]∼[aː] used). Each word appeared in 2 pairs of carrier sentences: one carrier sentence consisting of front vowels, the other consisting only of back or neutral vowels (different sentences for each test stem).

Each sentence had 2 variants: one contained the target stem with a front suffix, the other with a back suffix. This yielded 4 instances of each stem, and 120 sentences in total.

The 4 instances of the word *fotel* /fotɛl/ ‘armchair’ are shown in Table 2 below.

	front sentence	back sentence
back suffix	*Egy ilyen* ***fotelban*** *kényelmetlen ülni.*	*A hátsó* ***fotelban*** *alszik valaki.*
front suffix	*Egy ilyen* ***fotelben*** *kényelmetlen ülni.*	*A hátsó* ***fotelben*** *alszik valaki.*
	‘It is uncomfortable to sit in an armchair like this.’	‘There’s somebody asleep in the armchair in the back.’

Table 2: Test sentences containing the word *fotel* /fotɛl/ ‘armchair’

We conducted a web-based survey with Experigen (Becker and Levine 2010). Each participant viewed all sentences in a different random order, and was asked to judge the grammaticality of each sentence on a scale of 1 to 5, with 5 being the best and 1 the worst.[6] The initial instructions attempted to counteract the overwhelming linguistics prescriptivism present in both countries. A mini-questionnaire at the end of the judgement task asked participants about their country of residence, age, and, optionally, their contact information.

2.1.3. *Participants*

We had a total of 23 participants for our survey. Five of these were excluded according to pre-determined criteria: either because the participant’s country of residence was not Hungary or Slovakia (typically, these were Hungarian speakers from Transylvania), or because the participant provided less than 100 of the total 120 judgements.

Thus, 18 participants remained, nine from Slovakia and nine from Hungary. They had no training in linguistics, and were between the ages of 23 and 57 years.

[6]We chose a 1 to 5 scale because the school grading system in both countries uses such a scale. In the Hungarian school system, 5 is the best grade and 1 is the worst, while the Slovak system uses these grades in the reverse order. We considered reversing the scale for the Slovakian speakers for this reason, but deemed it unnecessary after some informal tests with two of our Párkány subjects indicated that Hungarian-type scale is unproblematic for them.

2.2. *Results*

Figures 4 and 5 show how our pre-categorisation of stems corresponds to speakers' responses, for Budapest and Párkány speakers, respectively. The y axis shows the mean scores of a stem with a back suffix subtracted from the mean score of the same stem with s front suffix ('frontness'), while stem types are arranged along the x axis according to their scores. The stems we categorised as back are represented with a blue letter B, vacillating stems with a black **V**, and front stems with a red F.

We can see that our pre-categorisation corresponds fairly well to the participants' judgements, with the exception of one stem, *fiktív* /fikti:v/ 'fictitous', which we categorised as front, but it appears among vacillating stems with a frontness score slightly below zero in Figure 5 (Párkány speakers).

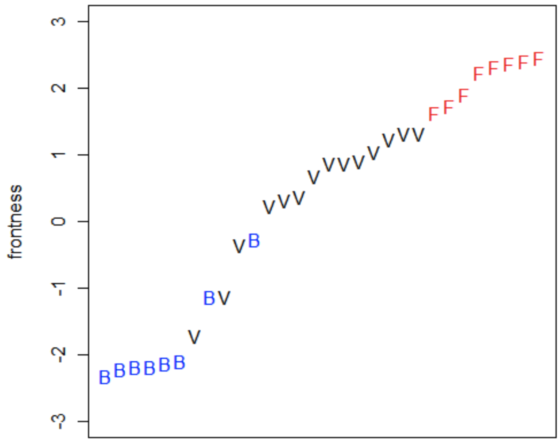


Figure 4: Categorisation of stems by Budapest speakers

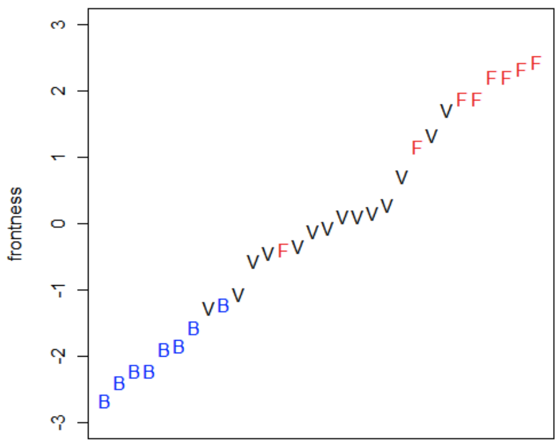


Figure 5: Categorisation of stems by Párkány speakers

Figures 6-8 show individual Budapest speakers' scores for back, front and vacillating stems, respectively. The codes consisting of three letters and a number identify each speaker across the three tables. On the x axis, the frontness of the suffix is shown (back suffixes on the left, front suffixes on the right). The y axis shows the score assigned by each speaker to stems with the corresponding suffix variant.[7]

Figures 9-11 show individual Párkány speakers' scores for back, front and vacillating stems.

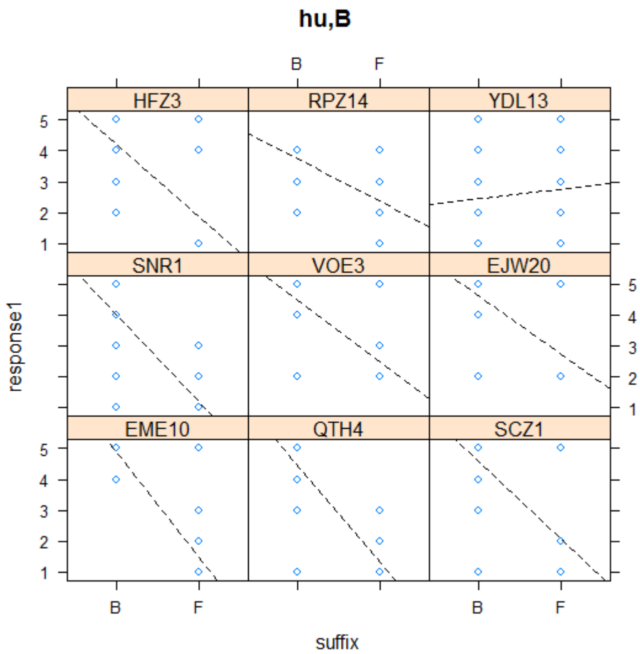


Figure 6: Suffix choice for back stems, Budapest speakers

[7]Note that the judgements of speaker YDL13 markedly differ from the other speakers' scores for back and front stems; nevertheless, we did not exclude this speaker from our analysis, since (s)he matched the two pre-determined criteria described in section 2.1.3.

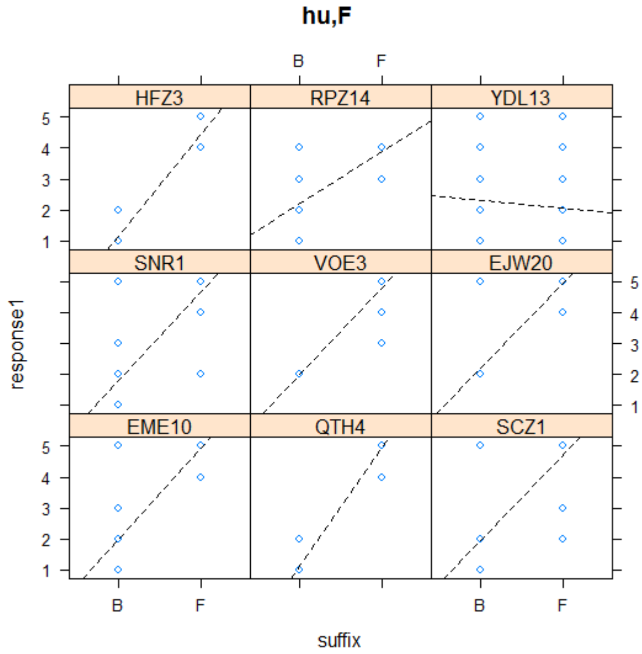


Figure 7: Suffix choice for front stems, Budapest speakers

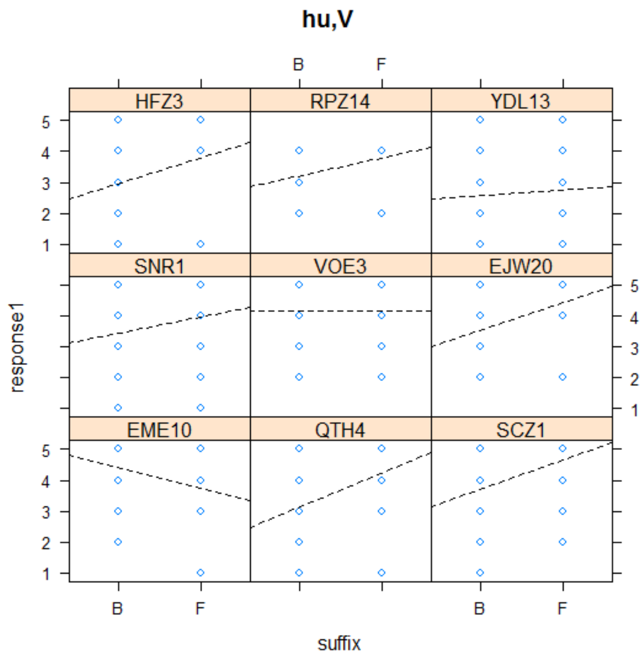


Figure 8: Suffix choice for vacillating stems, Budapest speakers

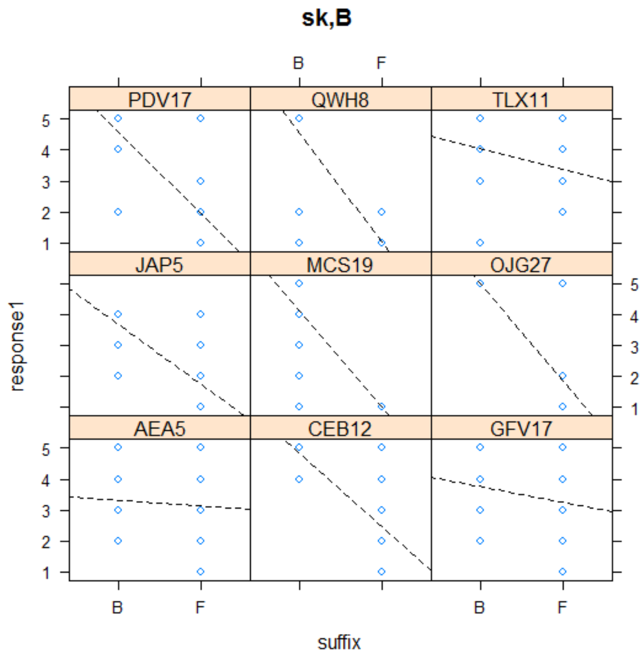


Figure 9: Suffix choice for back stems, Párkány speakers

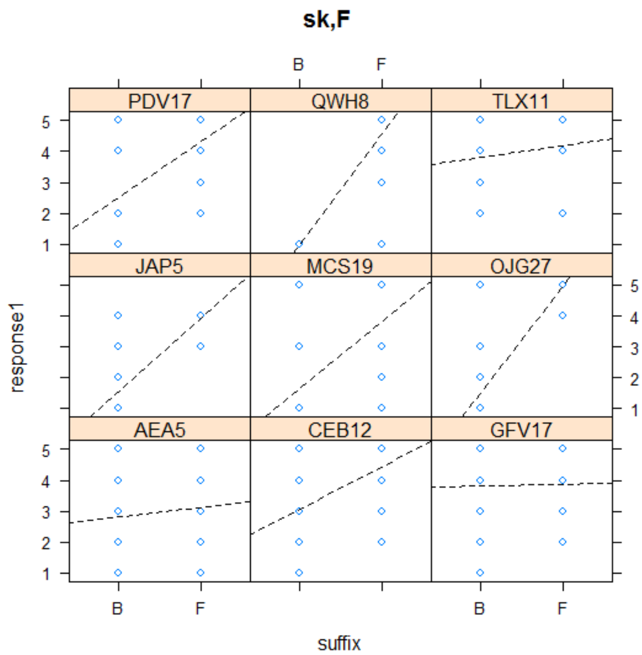


Figure 10: Suffix choice for front stems, Párkány speakers

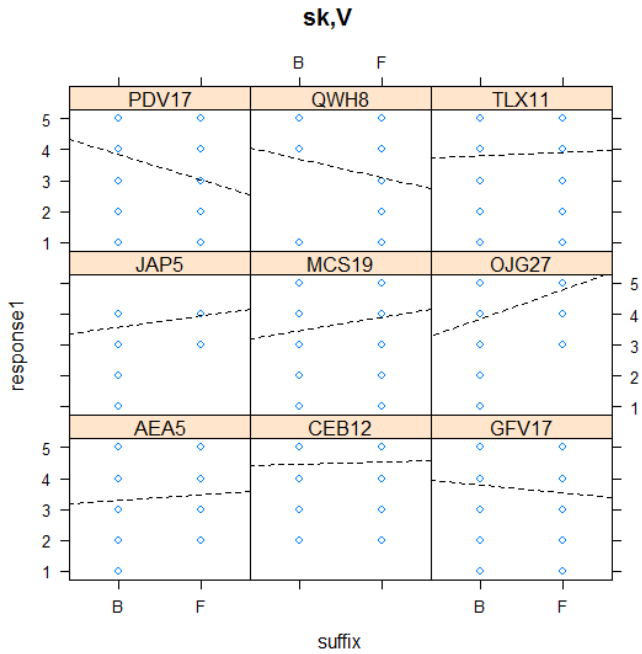


Figure 11: Suffix choice for vacillating stems, Párkány speakers

Figure 12 shows a comparison of Budapest (blue) and Párkány (green) speakers' judgements for vacillating stems. Estimated marginal means are shown on the y axis, while the type of suffix is represented on the x axis (back suffixes on the left, front suffixes on the right). A visual inspection already hints at a difference between the speakers of the two dialects: Párkány speakers (green) give nearly equal scores to vacillating stems with back suffixes and vacillating stems with front suffixes, while Budapest speakers (blue) prefer front suffixes with vacillating stems. Statistical analysis confirms that the difference between the two dialects is significant ($F(11,2147)=84.77$, $p<0.001$).

In addition, a multi-way ANOVA was carried out with the following factors:

- `dialect` — Budapest or Párkány;
- `vowel` — /i/, /iː/, /ɛ/∼/e/ or /eː/;
- `stem type` — front, back or vacillating;
- `suffix type` — front or back suffix variant;
- `context` — carrier sentence containing front or back vowels.

We found that context did not have a consistent influence for either group of speakers, that is, whether the other words in the carrier sentence contained mostly front or mostly back vowels did not influence the participants' ratings (cf. Ringen 1978 on deictic phrases).

Regarding overall preferences of the suffix vowel, words with front suffixes were judged to be better than words with back suffixes. Párkány speakers gave words with back suffixes better scores that Budapest speakers did, although it should be noted that Párkány speakers gave higher points in general than Budapest speakers did.

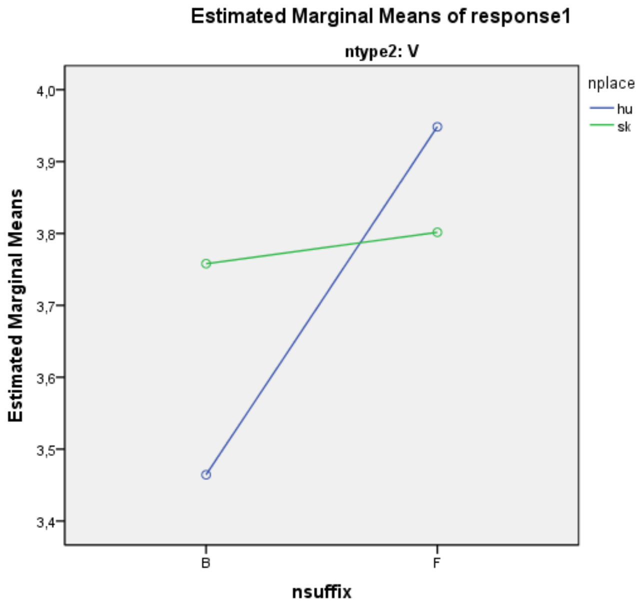


Figure 12: Comparison of suffix preferences of Budapest and Párkány speakers for vacillating stems

Examining the effect of the type of the neutral vowel yielded controversial results with respect to the Height Effect: stems with /ɛ/-/e/ and /i/ prefer front suffixes, unlike /eː/ and /iː/ (recall that the Height Effect states that the lower the vowel, the higher the preference for a front suffix).

3. Acoustic study[8]

An acoustic study was done to address the question of whether the small articulatory effects discussed by Beňuš and Gafos are present acoustically. These articulatory effects can cause acoustic differences in F2, although the connection between the two is not linear. Lack of an acoustic effect would question an analysis of the phenomenon with lexically stored distinction between a full and a retracted neutral vowel, because there would be a serious problem with how this distinction is learned.

3.1. Methodology

The data analysed in this section come from an experiment for an ongoing study by the authors, designed to acquire data about the acoustics of transparent vowels and vowels in antiharmonic stems and judgments about transparency in two dialects of Hungarian (Blaho and Szeredi 2011; 2012b;a). So far, only the antiharmonic data have been analysed for the full set of 12 speakers — these results are discussed below.

3.1.1. Participants

Twelve subjects participated in the study: 7 from Budapest, who speak the standard colloquial dialect, and 5 from Párkány (Slovakia).

[8] A more detailed desription of this experiment can be found in Szeredi (2012).

3.1.2. Stimuli

The stimuli of the experiments included target words which tested harmonic and antiharmonic neutral vowels.[9] The stimuli relevant to this section are shown in Table 3. These stimuli were based on the target words of Beňuš and Gafos (2007), but several smaller changes have been made for the acoustic experiment, so that the segmentation of vowels can be easier (eg. [biːr] instead of [iːr], [viːz] instead of [iːz]), or that the target words can be paired to each other more simply (eg. [ʧiːp] instead of [ʦiːm] to match up with [ʃiːp]). The tokens marked with an * are the new words used in this experiment.

harmonic	**antiharmonic**
iːv 'spline'	viːv 'fence.3sg'
hiːr 'news'	biːr* 'carry.3sg'
viːz* 'water	hiːd 'bridge
ʧiːp* 'pinch.3sg'	ʃiːp 'whistle'
his 'believe.3sg'	ɲit 'open.3sg'
eːj 'night'	heːj 'crust'
seːl 'wind'	ʦeːl 'aim'

Table 3: Stimuli of the experiment to test antiharmonicity

3.1.3. Presentation

The experiment was conducted by seating the subjects in a quiet room, and presenting them with a randomised list of all the stimuli listed in Tables 3 three times, embedded in the frame sentence [ɒst montɒm X. mɛgiʃmeːtlɛm X] 'I said: X. I repeat: X'. The randomization and the presentation was conducted with the web-based experiment presentation software Experigen (Becker and Levine 2010).

The recordings were made using a Shure WH 30 head-mounted cardioid condenser microphone with a Tuscam US-144MKII pre-amplifier for the Párkány speakers and one Budapest speaker, and a Sennheiser ME3-ew head-mounted condenser microphone for the Budapest speakers with an Alesis io | 2 preamplifier. The recordings were made with Praat (Boersma and Weenink 2010) and Audacity (Audacity Team 2009).

3.1.4. Data Analysis

Segmentation and measurements were made using Praat (Boersma and Weenink 2010)[10]. The quality of the vowel was measured at the midpoint, measurements made were F1, F2, F3 formants, F0 and intensity. Statistical analysis on the results was performed in R (R Development Core Team 2012). An example of how the segmenting was done is seen in Figure 13.

Unfortunately, the recording conditions were not perfect and there was a little noise in the recordings which caused the formant tracker to accidentally find an F2 between F1 and the actual F2 curve. These 'phantom' F2 measurements were corrected by substituting the F2 value with the measured F3 value (the actual second formant) for all data where the measured F2 was below 1000 Hz for males and 1500 Hz for females. This had to be amended with repeating this protocol for two high-pitched female speakers for all F2 below 1750 Hz. The resulting F2 distribution is highly negatively skewed ($s^3 = -1.16, Z = -6.97, p < 0.001$) for male speakers, suggesting that more erratic tokens might still be in the data. However, the sample for female speakers has a small, although significant positive skewing ($s^3 = 0.41, Z = 3.48, p < 0.001$), indicating that this manipulation might have introduced a little floor effect, but not too much to introduce a high positive skew to the data.

[9]The vacillating stems used in the grammaticality judgement experiment discussed above were also included in the set of stimuli for the acoustic experiment. However, those results are not discussed in this paper.

[10]We thank our research assistant Ádám Szalontai, who conducted the segmentation.

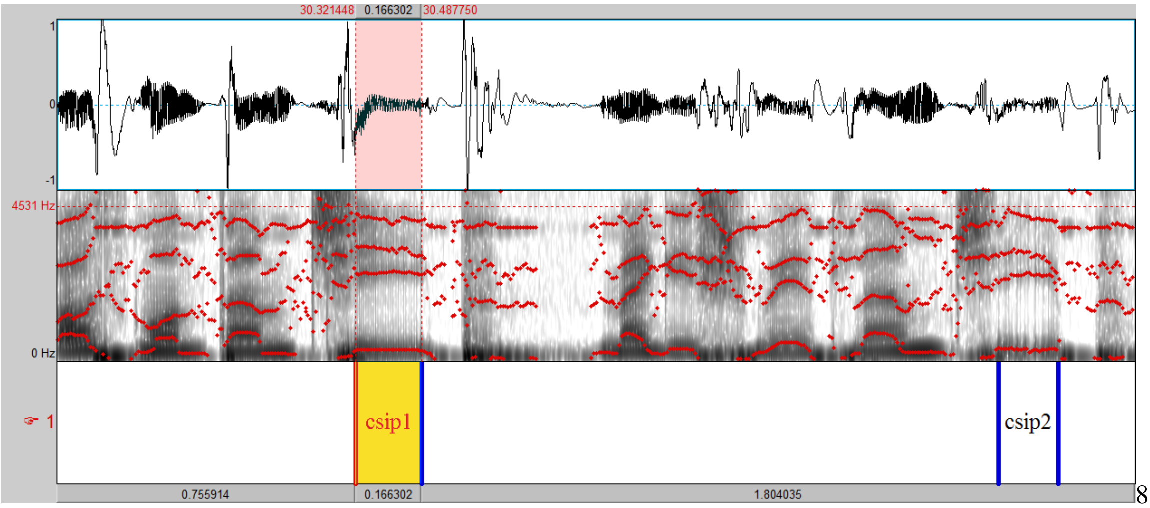


Figure 13: Segmenting the sentence [ɒst montɒm **ʧiːp**, mɛgiʃmeːtlɛm **ʧiːp**]

3.2. Results

Every token was coded with the following factors: `f1`, `f2`, `f3` as measured variables and `speaker`, `gender`, `word` (the item-wise grouping factor), `repetition`, `harmony` and `dialect` as item or speaker specific factors.

As each sentence contained the target word twice, the first one was coded with 1, and the second one with 2 in the `repetition` factor. The `dialect` factor determined whether the speaker was from Budapest or Párkány. The key independent variable of the analysis was `harmony`, which was set as `front` for the harmonic, and `back` for the antiharmonic stems.

In the analyses below, only `f2` was used from the measured variables as the dependent variable: if antiharmonic stems were acoustically different from harmonic stems, a main effect of `harmony` should be significant in the statistical analysis. The possibility that vowel height is also affected was also entertained, however, even a less conservative mixed effects ANOVA with `harmony` as a within-subjects factor and `subject` as between-subjects factor did not indicate that `harmony` is a significant effect for `f1` (F(1,11)=0.19, p=0.67), and mixed effects regression also showed that harmony type does not affect F1 ($\beta = 7.623$ Hz, SE = 19.122, t=0.339 for the saturated model; $\chi^2(1) = 0.158$, p=0.69 with backwards stepwise term elimination).

The grand mean difference between harmonic and antiharmonic stems in the data was 23.388 Hz. Some other relevant mean values for this difference are shown in Table 4. To find out whether these differences can be significant overall, or for some of the speakers, more detailed statistical analyses were made, which are presented in the following sections.

3.2.1. Regression analysis on the dataset

The very small effect size, and the apparently large between-subjects variation which is hard to attribute to gender and dialect only, and the lack of an item-wise random effect justifies the need for a detailed investigation of the data. The amount of between-speaker variation can be seen in Figure 14. A linear mixed effects regression was fit using the **lme4** package for R (Bates et al. 2011).

The fully saturated model is shown in (25).

overall	gender		dialect		speaker			
23.4	male	5.8	Budapest	18.6	1	59.3	7	32.5
	female	15	Párkány	29.9	2	19.9	8	59.1
					3	2.8	9	-0.6
					4	-9.5	10	61.0
					5	-9.9	11	-18.1
					6	-1.2	12	-7.8

Table 4: Mean differences in F2 between harmonic and antiharmonic stems. Positive values denote higher F2 values for harmonic stems (the expected direction)

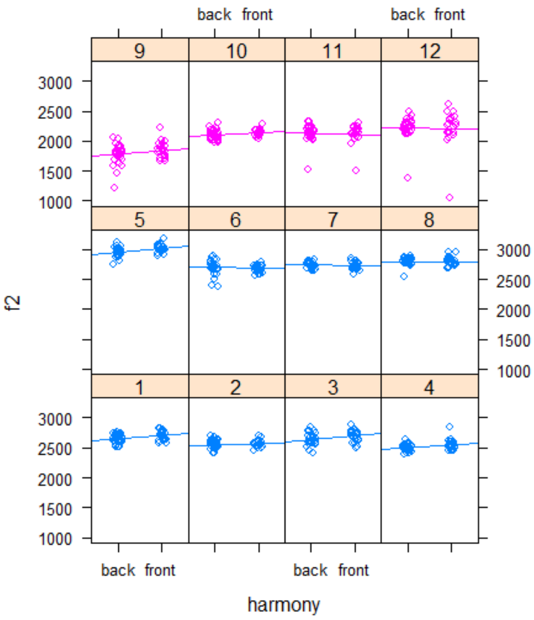


Figure 14: Between-speaker effect of `harmony` on `f2` (pink = male speakers, blue=female speakers).

(25) `f2 ~ harmony * gender * dialect * repetition +(1 + harmony * repetition | speaker) +(1 + gender * dialect * repetition | word)`

The model does not contain random slopes for `gender` and `dialect` by `speaker`, because these variables are hierarchically nested under `speaker`, so a value for a random slope for `gender=male` for a given male speaker would not be interpretable, and the between-speaker variation would be vaguely distributed between the random intercept and these nested random slopes. The same reasoning led to the exclusion of a random slope for `harmony` by `word`.

Investigating the coefficients of this model leads to questioning the overall significance of `harmony` in the data: the coefficient of `harmony=front` is $\beta = 23.836$ Hz with a standard error of 27.062 Hz (t=0.88). There are non-significant interactions with positive sign – meaning that they would imply a preference for a higher F2 with harmonic stems if they were significant. This is seen in the data with males (`harmony=front & gender=male`: $\beta = 24.87$, SE=59.28, t=0.42), speakers from Párkány (`harmony=front & dialect=sk`: $\beta = 39.39$, SE=48.86, t=0.81), and in the four-way interaction of Párkány male speakers in their second repetition (`harmony=front & gender=male & dialect=sk & repetition=2`: $\beta = 72.413$, SE=94.8, t=0.76).

There are also non-significant interactions with a negative sign: in the second repetition (`harmony=front & repetition=2`: $\beta = -5.364$, SE=28.866, t=0.19), with male speakers from Párkány (`harmony=front & dialect=sk & gender=male`: $\beta = -86.8$, SE=83.04, t=1.05), males in the second repetition (`harmony=front & gender=male & repetition=2`: $\beta = -27.4$, SE=69, t=0.4) and speakers from Párkány in the second repetition (`harmony=front & dialect=sk & repetition=2`: $\beta = -14.12$, SE=60.34, t=0.23).

The only significant effect for the saturated model judging by t values was `gender=male`: $\beta = -642.184$, SE=158.09, t=4.06.

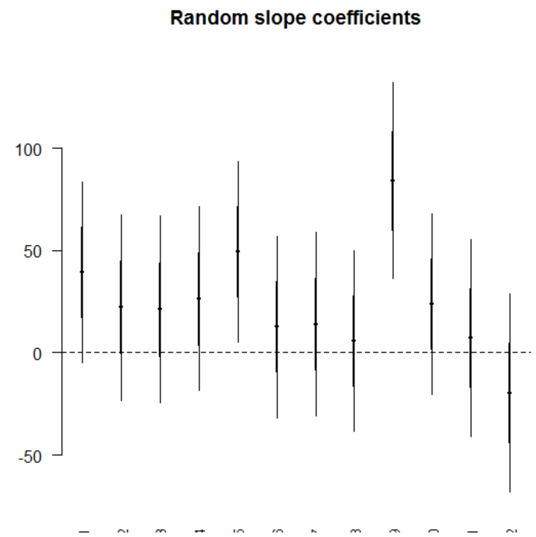


Figure 15: Random slope coefficients for `harmony=front` by `speaker` in the saturated model.

The random slope coefficients assigned to `harmony` by `speaker` are shown in Figure 15. Most speakers seem to have a positive coefficient, albeit not significant. Speaker no. 9 has a uniquely high coefficient, which is in return offset in the random slope of `harmony:repetition`, for which speaker no. 9 had a significantly low coefficient, while other speakers' coefficients hover around 0. This irregularity might be due to some formant tracking measurement errors, which accidentally grouped together such as unusually low F2 was measured for antiharmonic and unusually high F2 was measured for harmonic stems in the first repetition. This effect of noise can be seen on Figure 16.

Having examined the saturated model, a backward stepwise term elimination procedure was done, where the highest level interactions were eliminated if their removal did not affect the likelihood of the model significantly. This was iterated until only the main effects were in the fixed effects structure, as no interactions came out as significant. The random model structure was simplified using the same method, removing not only interactions but random slopes of effects as well. A significant random slope that was not removed from the model was `harmony | speaker` ($\chi^2(3) = 39.288$, p< 0.001), where the pattern is seen in Figure 17, with speaker no. 9 still having a significant positive coefficient, though the interaction term had been eliminated. The other random slope term not removed from the model was `dialect | word`, which was scraping significance at an $\alpha = 0.1$ level ($\chi^2(4) = 7.822$, p=0.098), but conservativity dictates that this term should be kept. The resulting baseline model is shown in (26) below.

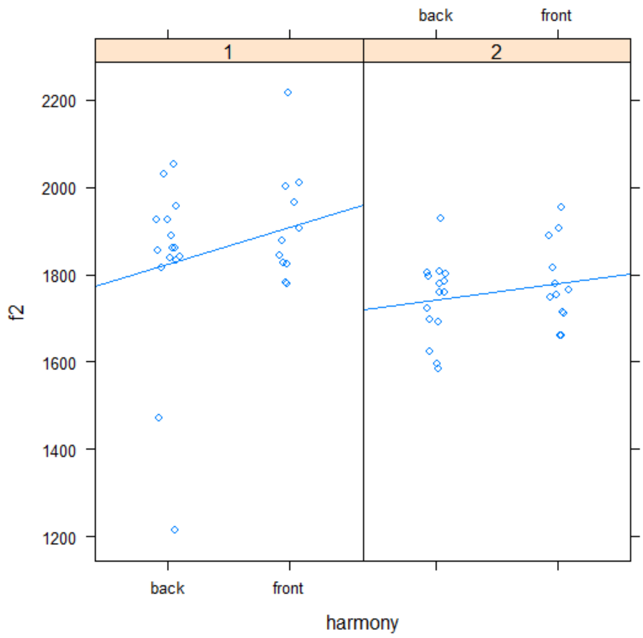


Figure 16: The effect of some outliers: F2 measurements of speaker no. 9 by repetition. Some outlying measurements for the first repetition (on the left side) affect the `harmony:repetition` interaction largely for this speaker.

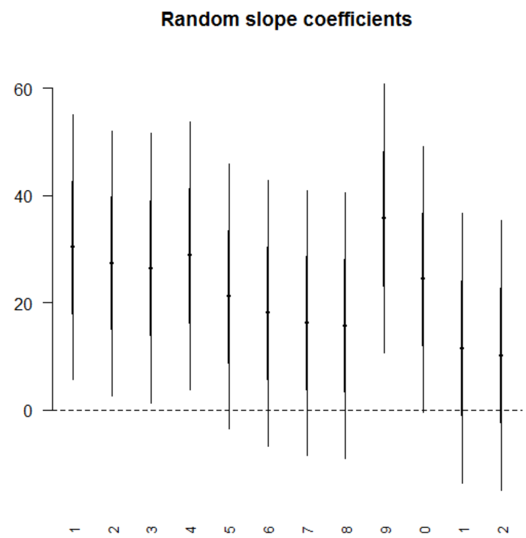


Figure 17: Random slope coefficients for `harmony=front` by `speaker` in the final baseline model.

(26) `f2 ~ harmony + gender + dialect + repetition + (1 + harmony | speaker) + (1 + dialect | word)`

The significance of main effects was tested again by comparing the model with the removal of a given term to the baseline, and finding out whether the likelihood worsened significantly. Again, `harmony` was not a significant main effect ($\chi^2(1) = 2.01$, p=0.156), nor was `dialect` ($\chi^2(1) = 1.245$, p=0.26) and `repetition` ($\chi^2(1) = 0.0591$, p=0.81). The factor `gender` was obviously still significant ($\chi^2(1) = 17.44$, $p < 0.001$). By removing the non-significant main effects of `dialect` and `repetition` from the fixed effects structure of the baseline model, the χ^2 score of `harmony` can be further raised to 2.385 (p=0.122).

Summarizing the results above, no acoustic difference was found corresponding to the articulatory effect described by Beňuš and Gafos (2007), which would lead to antiharmonic stems being more retracted. Although it seems that the direction of the effect is consistent with the hypothesis, the size of this effect is very small, and this effect is not significant when analyzing the data with linear mixed effects regression, thus assigning random variance to subject-wise and item-wise random effects. It is also visible from the study of random slopes by speaker that not all of the subjects show the same pattern: some speakers actually do not go in the expected direction.

3.2.2. Discussion

The results have shown again, that the articulately effect found in Beňuš and Gafos (2007) is not reflected in the acoustic data. Although the effect of lower F2 in antiharmonic stems can be found in some subsets of the data, contradicting patterns can be found as well. Looking at the overall data, no significant effects appear, as the relevant variance in the data is assigned to different random effects. This fact, and the very small size of the mean difference suggest that the effects of the articulatory difference explored by Beňuš and Gafos (2007) are not there in the acoustics.

The finding that some speakers do show an effect in the expected direction could indicate, however, that the possibility of the presence of an acoustic difference in a subset of Hungarian speakers can be still considered. Two questions would arise if there is still an effect: if these small acoustic differences are there, how are they perceived (can they be perceived), and can they be learned?

In order to test this, a perception experiment was carried out by Szeredi (2012). The results indicate that Hungarian speakers do not utilise a 100 Hz difference in F2 in order to determine the harmonic/antiharmonic categorisation of nonce stems.

4. Summary and further research

In this paper, we examined the morphophonological and acoustic properties of neutral vowels, focusing on vacillating and antiharmonic stems. Our results show a dialectal difference between Budapest and Párkány speakers: the former prefer front suffixes for vacillating stems, while the latter give similar well-formedness judgements for vacillating stems with front and back suffixes.

We also investigated whether the articulatory difference between vowels in harmonic and antiharmonic stems reported by Beňuš and Gafos (2007) has a consistent manifestation in the acoustics, and found that no such effect can be clearly identified. Naturally, not finding such a difference is no refutation of the proposal that it might exist, but it weakens such claims as the very least.

It is clear that more research is necessary to answer the question whether the phonetic properties of different sets of neutral vowels cause their morphophonological behaviour or whether it is an underlying difference between these groups of vowels that is manifest in the phonetics. We are running the experiments presented in this paper to include more speakers, as increasing the sample size will reduce the risk of statistical artefacts being interpreted as valid results. In addition, the perception experiment by Szeredi (2012) is also planned to be extended to test for more fine-grained distinctions that speakers might be sensitive to.

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