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Laryngeal contrast and phonetic voicing

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Chapter 6

Experiment 2: regressive voicing assimilation in Hungarian

„1. A' Páros Kemények nem szenyvedhetik magok előtt a' sebes ki mondásban a' Páros Gyengéket, hanem azokat fel tserélik-az ő Keménypárjaikkal. A' Liquidákkal pedig széretik.

2. A' Páros Gyengék nem szenyvedhetik magok előtt a' Páros Keményeket, hanem azokat fel tserélik az ő Gyenge Párjaikkal. A' Liquidákat pedig szeretik.” (Kolmár 1821: 57)

“1. The paired strong ones [i.e., sounds] cannot bear the paired weak ones to be in front of them in fast speech; rather they trade them up for their strong twin. With liquids however, they get on well.

2. The paired weak ones cannot bear the paired strong ones to be in front of them in fast speech; rather they transpose them for their weak twin. Liquids however, they love.”¹

It should not be difficult to motivate Hungarian as a second test case for a coarticulation-based theory of RVA. As the surrounding Slavonic languages and neighbouring Romanian, Hungarian is a voicing language, but in contrast to (most) of the former it lacks a process of across-the-board final laryngeal neutralisation. Assuming for the sake of the argument that *voicing language* and *aspirating language* are coherent notions with regard to the behaviour of word-final stops, it therefore differs from English in terms of just a single variable. Thus, it allows for exactly the same set of hypotheses to be examined as those that were investigated with the previous experiment.

¹Translation by Zoë Toft.

Hungarian possesses a well-documented process of regressive voicing assimilation that is attracting increasing attention in the generative literature. A coarticulation-based theory derives the following set of predictions concerning (the phonetic manifestation of) Hungarian regressive assimilation at word boundaries (cf. 15 above and 11 in chapter 4):

- (18) Predictions of a coarticulation-based approach to voicing assimilation regarding obstruent sequences in Hungarian
- a. Hungarian obstruents fall into 2 classes in terms of their influence on (the voicing of) a preceding obstruent. (1) fortis obstruents trigger devoicing (relative to a ‘neutral’ environment); (2) lenis stops and fricatives cause an increase in the voicing of a preceding obstruent, because both classes are actively (pre)voiced (11c)
 - b. The assimilatory effects of fortis obstruents and lenis fricatives are limited to voicing and features mechanically dependent on the production of voicing distinctions. Cf. (11a)
 - c. Hungarian RVA at word boundaries is a gradient process that is not neutralising in most instances Cf. (11b)

In other words, the phonetic theory predicts that Hungarian RVA behaves in a fundamentally identical fashion to English regressive voicing assimilation except in a single respect: the lax stops /b, d, ʒ, g, d̥/ should cause an increase in the voicing of a preceding obstruent vis-à-vis a neutral (passively voiced sonorant) environment.

The experiment presented here was designed to test the three hypotheses in (18) against the predictions of a lexical feature analysis. The results of this experiment show that, as in English, regressive voicing assimilation between independent words is a non-neutralising process in Hungarian. However in contrast to the findings on English reported above, the Hungarian data contradict prediction (18b): vowel length distinctions between underlying /k/ and /g/ are near-neutralised when another obstruent follows. The duration of vowels preceding these sequences seems to cue neither the underlying laryngeal specification of the velar stops, nor the laryngeal specification of the obstruents following them, which means that the behaviour of vowel length cannot be regarded as assimilatory in the most straightforward interpretation of the term. Nevertheless, the observations on this point indicate that Hungarian RVA cannot be regarded as a purely coarticulatory process, but may be in part phonologised.

Note that the work reported in this chapter represents part of ongoing collaborative work with Zoë Toft: an earlier report can be found in Jansen & Toft (2002).

6.1 Background

Hungarian is an Uralic (Finno-Ugric, Ugric) language spoken by around 15 million people in Hungary and (as a minority language) in several of the surrounding states. As shown in (19) the obstruent system of Hungarian is bifurcated in the way that is familiar from Germanic and Romance (Kenesei et al., 1998; Siptár & Törkenczy, 2000).² According to Kenesei et al. (1998) the fortis stops and affricates of Hungarian are voiceless unaspirated while its lenis stops are prevoiced, and this is corroborated by acoustic data (Meyer & Gombocz, 1909; Gósy, 1999). The same authors characterise the parallel contrast in the fricative inventory as voiceless vs. voiced.

(19) The Hungarian obstruent system

	Labial		Alveolar		Postalveolar	Palatal		Velar	
Plosive	p	b	t	d		c	ç	k	g
Affricate			ts	(dz)	tʃ	dʒ			
Fricative	f	v	s	z	ʃ	ʒ			

Just as Yiddish and French, Hungarian preserves the distinction between word final tense and lax obstruents before sonorants and utterance finally. As would be expected under a phonetic theory of the phenomenon, tense and lax obstruents trigger regressive assimilation in obstruent clusters. Hungarian RVA is invariably described as largely symmetric with regard to both [tense] and manner of articulation: with the exception of /v/ all obstruents trigger the process. According to many descriptions it is insensitive to juncture strength and is obligatory in all sandhi obstruent clusters as long as no physical pause intervenes. The examples in (20) are from Kenesei et al. (1998) and Siptár & Törkenczy (2000).³

There is a long tradition in Hungarian linguistics that regards regressive voicing assimilation not only as obligatory but also as phonetically neutralising (Hall, 1944; Sauvageot, 1951; Kálmán, 1972; Lotz, 1972, 1988; Siptár, 1991; Olsson, 1992; Kenesei et al., 1998). Kenesei et al. (1998) and Siptár & Törkenczy (2000) emphasise this view by contrasting RVA with a process of regressive place assimilation that affects sibilant fricatives and affricates. Unlike voicing assimilation the latter phenomenon, which is exemplified by several of the forms in (20) (e.g., /bridʒ/ + /sobɔ/ → [brɪtʃsɔbɔ]), is said to be partial

²The inclusion of [dz] in the lexical obstruent inventory of Hungarian remains contentious: Siptár & Törkenczy (2000) argue that on phonological grounds it should be treated as a cluster, but Mária Gósy (p.c.) points out that most Hungarian phoneticians treat it on a par with [ts, tʃ, dʒ].

³On the basis of a transcription study, Gósy (1999) attempts to demonstrate that Hungarian RVA does apply across certain pauses, but her claims are hard to evaluate as no acoustic definitions to distinguish 'assimilated' from 'unassimilated' obstruents are provided.

and dependent on speaking rate and style. Only a few authors disagree with this assessment, and their objections tend to concentrate on the claim that Hungarian RVA is obligatory: both Kolmár (1821) and Vago (1980) suggest that the process is governed by speech rate, whilst Tompa (1961) claims that it can be suspended in loanwords and when a potential trigger belongs to a contrastively stressed word.

- (20) Regressive voicing assimilation in Hungarian (data from Kenesei et al. 1998:445-446 and Siptár & Törkenczy 2000:78)

a. [+tense][−tense] clusters

UR	Phonetic form	Gloss
/kɔlɒp/ + /bɔn/	[kɔlɒb:ɔn]	in (a) hat
/ku:t/ + /bɔn/	[ku:dbɔn]	in (a) well
/fy:c/ + /bɔn/	[fy:ʃbɛn]	in (a) whistle
/ʒa:k/ + /bɔn/	[ʒa:gbɔn]	in (a) sack
/okɔf/ + /zɛnɛ:s/	[okoz:ɛnɛ:s]	smart musician
/kova:tʃ/ + /zolta:n/	[kova:dzzolta:n]	Kovács Zoltán (proper name)
/vɛs/ + /dʒɛmɛt/	[vɛʒdʒɛmɛt]	buy-3.SG.INDEF jam-ACC.
/pɔlo:tʃ/ + /dʒida:f/	[pɔlo:dʒida:f]	Northern Hungarian lancer

b. [−tense][+tense] clusters

UR	Phonetic form	Gloss
/rɔb/ + /to:l/	[rɔptɔ:l]	from (a) prisoner
/ka:d/ + /to:l/	[ka:tɔ:l]	from (a) bathtub
/a:ʃ/ + /to:l/	[a:cto:l]	from (a) bed
/mɛlɛg/ + /to:l/	[mɛlɛktɔ:l]	from (the) heat
/monta:ʒ/ + /sɛry:/	[monta:sɛry:]	montage-like
/igɔz/ + /ʃa:g/	[igɔ:f:a:g]	truth
/bridʒ/ + /sobɔ/	[britssobɔ]	bridge room
/vɔra:ʒ/ + /tsɛruzɔ/	[vɔra:stɛruzɔ]	magic pencil

Whilst Hungarian regressive voicing assimilation has received considerable attention in the recent generative literature, there do not seem to be any quantitative phonetic studies of the process.⁴ Gósy (1999) is essentially a transcription-based study, although it is in part based on acoustic rather than impressionistic auditory data. Early work by Meyer & Gombocz (1909) provides some data on segmental duration in (lexical) obstruent clusters, but does not specifically

⁴Recent generative work includes Siptár (1996), Szigetvári (1998), Ritter (2000), Siptár & Törkenczy (2000), Siptár & Szentgyörgyi (2002).

investigate assimilation. Consequently, the only material that is available for comparison with the data reported below comes from languages with obstruent systems that are phonologically and phonetically similar to that of Hungarian, such as French (O. Thorsen, 1966) and Syrian Arabic (Barry & Teifour, 1999). Interestingly, these studies show that regressive voicing assimilation is incompletely neutralising in they investigate.

6.2 The Experiment

6.2.1 Methods

Subjects Subjects were 4 native speakers of Hungarian, all female, and aged between 26 and 30 years. All speakers were living in London at the time of recording and had lived in the United Kingdom for up to 4.5 years. None of the subjects reported a history of speech or hearing difficulties but (unavoidably) all of them were proficient to a greater or lesser degree in one or more languages besides Hungarian. Subject K9 grew up in Heves county but describes her speech as ‘standard’ (Budapest) Hungarian. She is fluent in English. Subject M15 also describes her variety of Hungarian as ‘standard’, despite having frequently moved around Hungary. This subject describes herself as ‘near-bilingual’ in French and has good English. Subject I16 is a bilingual Hungarian and Slovak speaker from Bratislava. She is fluent in English and has some knowledge of Czech and German. Subject A17 finally, is from Tatabánya, fluent in English, and has a good knowledge of both French and German. She had lived in the United Kingdom for approximately 6 years at the time of recording.

Materials The stimuli for experiment 2 consisted of consonant clusters combining a /k, g, ʃ, ʒ/ C₁ and a /t, d, s, z/ or liquid (/l/ or /r/) C₂. As in experiment 1 stimuli containing a sonorant C₂ were included to create baseline conditions for the comparison of the relative effects of fortis vs. lenis C₂ on the properties of a preceding obstruent. Velar plosive + alveolar obstruent clusters were used for the reasons specified in section 5.3 and also to facilitate comparisons with the English results. The set of obstruent contexts used for the English experiment was expanded somewhat by including the postalveolar fricatives /ʃ, ʒ/ in the C₁ set. Postalveolar fricatives were chosen to minimise the variation in C₁ place of articulation and for segmentation reasons (but see below).

C₁ consonants were preceded by a long vowel or short vowel + glide sequence (phonetic diphthong) from the set /eɪ, aɪ, uɪ, ɔj/, or one of the following short vowels: /i, ɔ, o/. Long vowels and short vowels were evenly distributed across C₁ and C₂ laryngeal specifications and manners of articulation in order to avoid a bias of underlying vowel length in the effects of these factors on vowel

duration. Similarly, high and non-high vowels were evenly distributed across C_1 and C_2 laryngeal specifications and manners of articulation in order to control for effects of vowel height on C_1 voicing duration and F_0 perturbations. The clusters were located at subject noun + verb boundaries in carrier sentences. As in experiment 1, no attempt was made to control for carrier word frequencies. Some sample stimuli are given in 21 in orthographic and phonological transcription.⁵ Target clusters appear slanted.

- (21) Hungarian sample stimuli
- a. A vak *darabolta* a húst
 /ɔ vɔk dɔrɔboltɔ ɔ hu:ft/
 The blind mince-PAST.3.SG the meat-ACC.
 The blind man minced the meat
 - b. A kés *dolgozik* a mészáros kezében
 /ɔ ke:f dolgozik ɔ me:sarɔs keze:bɛn/
 The knife works the butcher hand-3.POSS-in
 The knife works in the butcher's hand
 - c. A rizs *zöldül* a mezőn
 /ɔ riʒ zøldyl ɔ me:zø:n/
 The rice green-become the field-PL.-LOC.
 The rice turns green in the fields

Subject + noun boundaries were chosen over other possible word boundary environments on grounds of the available carriers for C_1 , which had to be similar in overall phonological make-up whilst exhibiting a robust contrast between /k, ʃ/ and /g, ʒ/ (and therefore had to be unsuffixed). One potential problem with this choice is that the type of boundary involved usually represents a strong phonological and phonetic juncture, and this is reflected in the number of utterances that had to be excluded because of a physical pause intervening in the target cluster, which was relatively high compared to the English corpus examined above. Strong junctures have a tendency of blocking sandhi processes and it might therefore be argued that the design of the experiment is inherently biased towards non-assimilation or incomplete assimilation (Peter Siptár, p.c.).

However, as can be gleaned from the discussion in chapter 4, it is not an objective of this study to prove that all forms of assimilation or even all forms of regressive assimilation of word boundaries are driven by coarticulation. Its main objective in this area is to investigate the weaker proposition that regressive assimilation at word boundaries either operates as a coarticulatory process or is diachronically grounded in such a process. A first and important step in this argument is to establish that there indeed is a coarticulatory form of regressive voicing assimilation. Since it seems to be typical for sandhi processes that

⁵The full stimulus set appears in appendix B.

operate across weak junctures to be subject to phonologisation, the behaviour of obstruent clusters at strong boundaries is therefore not just a legitimate testing ground for the phonetic approach to RVA proposed in chapter 4 but potentially a crucial one.

Note, moreover, that many descriptions of Hungarian RVA, including the one provided by [Siptár & Törkenczy 2000](#), suggest that the process is obligatory (and categorical) regardless of juncture strength as long as no physical pause intervenes. From this perspective, the present design is perfectly valid as long as tokens with a physical pause between C_1 and C_2 are removed from the corpus.

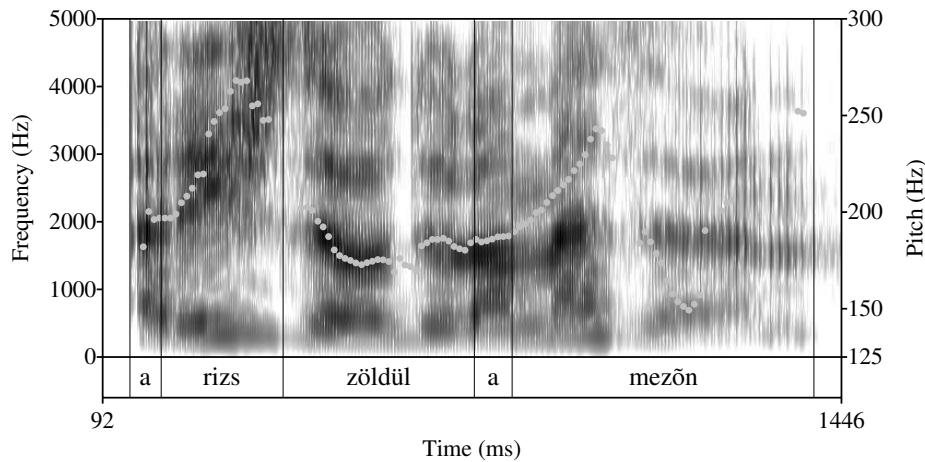


Figure 6.1: Experiment 2: pitch contour of responses. Broad band spectrogram of an utterance of the stimulus sentence in 21c with superimposed F_0 track. The speaker is subject I16.

It was impossible to construct all carrier sentences according to the neutral word order for the propositions they expressed. This raised the possibility that the subjects would assign different prosodic structures to different stimulus sentences. However, the great majority of responses was pronounced with a F_0 peak on the subject noun carrying C_1 followed by a gradual fall across the remainder of the sentence. A variant of this pattern (frequently used by subject I16 and illustrated in figure 6.1) shows what appears to be a secondary pitch accent on the initial syllable of the final word, but under neither of these two contours did the verb acting as the C_2 carrier receive any pitch prominence. Unfortunately, this limits the scope for comparison with the data from experiment 1 somewhat, as all the utterances in the English corpus were produced with a nuclear accent on the syllable containing C_2 .

Procedure The stimuli were presented to the subject in a quasi-randomised order to avoid consecutive stimuli with identical consonant clusters. The subjects produced three repetitions of each stimulus and were asked to read a stimulus again if they produced a mistake or hesitation that was clearly audible to the experimenter. In total, 2 (plosive C_1) * 5 (C_2) * 6 (stimuli) * 3 (repetitions) * 3 speakers + 2 (fricative C_1) * 5 (C_2) * 4 (stimuli) * 3 (repetitions) * 4 speakers = 1200 utterances were recorded. Only 4 stimuli each were used for the postalveolar fricative C_1 s because of a lack of suitable target words. Recording and acoustic analysis set-ups were the same as for the English experiment. 58 utterances had to be discarded because they contained a pause between C_1 and C_2 . In addition, all of the remaining 158 fricative + fricative sequences and 5 plosive + plosive clusters could not be internally segmented in any reliable fashion and had to be discarded too.⁶ This left 953 utterances for segmentation and analysis.

Segmentation and measurements Segmentation of the acoustic signals was carried out according to the protocol sketched in 5.3 above, with additional provisions for C_1 fricatives, which were not investigated in experiment 1. The onset of a C_1 fricative was defined as the onset of frication noise, or if present, the appearance of aspiration noise preceding it (cf. Stevens et al. 1992; Stevens 1998). The offset of a fricative C_1 in fricative + stop sequences was defined as the offset of frication noise.

Table 6.1: Acoustic measurements and derived measures for Experiment 2.

		Segment			
	V_1	C_1		C_2	V_2
(a)	Duration	(c) Closure duration (stops)	(h)	Closure duration (stops)	(m) F_0 10-50 ms after C_1 offset
(b)	F_0 50-10 ms before C_1 onset	(d) Release duration (stops)	(i)	Overall duration (fricatives)	
		(e) Overall duration	(j)	Voicing duration (fricatives)	
		(f) Voicing duration (2 m.)	(k)	Voicing ratio (fricatives)	
		(g) Voicing ratio (2 m.)	(l)	VOT (stops)	

⁶Hungarian sibilant + sibilant clusters are subject to a rule of regressive place assimilation that was mentioned above and illustrated in (20). In most of the fricative + fricative clusters in the present corpus this assimilation is partial (vindicating the description by Siptár & Törkenczy 2000 and others) but it nevertheless proved hard to define sufficiently precise criteria to segment C_1 from C_2 in these clusters.

The phonetic expression of [\pm tense] and regressive voicing assimilation was quantified in almost exactly the same way as for experiment 1: a summary of the relevant measures appears in table 6.1. Note that no measurements were made of F_1 preceding C_1 onset because the lexical vowel quality of V_1 could not be controlled for.

6.3 Results

The main results of experiment 2 are reported below in roughly the same order as the results of experiment 1 in 5.4 in order to facilitate a comparison of the results. The main focus is on the behaviour of C_1 plosives, in part to highlight similarities and differences with the English data reported above, and in part for practical reasons: the phonetic features of C_1 fricatives could only be examined before C_2 plosives and liquids, which results in a defective paradigm for comparison with C_1 plosives. It is unclear too, whether the segmental duration of fricatives can be meaningfully compared in quantitative terms with the durational features of plosives.

6.3.1 Phonetic features of C_2

The measurements of C_2 voicing are in full agreement with descriptions of Hungarian as a voicing language. /d/ has a negative VOT of 26 ms whilst /t/ has a short lag positive VOT of 23 ms. The amount of prevoicing in the lax stop may seem small in comparison with published data on other voicing languages, but note that the mean duration of the closure stage of /d/ is only 51 ms. The high standard deviation of the VOT for /d/ provides another clue to its mean value: 56 tokens (24.9%) of /d/ are completely voiceless. As 21 of these tokens are preceded by /ʒ/ the assumption seems warranted that this is the result of passive devoicing rather than a rule spreading [+tense].⁷ The mean VOT for /t/ is 9 ms longer than the value found for English /d/ in experiment 1, which is consistent with the hypothesis that short lag /d/ and short lag /t/ represent two distinct voicing categories: passively voiced and actively devoiced (2.2.1 above and cf. Raphael et al. 1995).

As shown in table 6.2, there is little unexpected about the behaviour of the fricatives /s/ and /z/. The former is wholly voiceless (there are a few tokens with a minute amount of voicing ‘spill’ from a preceding voiced obstruent) and relatively long whereas the latter is (partially) voiced and relatively short. The mean voicing ratio of /z/ (.65) is lower than that of English /z/ (.78), but since the latter but not the former was produced in a prosodically strong context it

⁷If fully devoiced tokens of /d/ are excluded, the average amount of prevoicing for this category increases to 42 ms.

Table 6.2: Experiment 2: duration and voicing of C_2 . Closure duration and VOT of /t, d/, and overall duration and duration of the voiced interval for /s, z/. All values in ms, and pooled across preceding contexts (/k, g, ʃ, ʒ/). Standard deviations in brackets.

C_2	VOT	Closure duration	N
/t/	23 (7)	59 (17)	232
/d/	-26 (30)	51 (14)	225
	Voicing	Duration	N
/s/	0 (2)	123 (22)	136
/z/	56 (31)	92 (18)	135

would be premature to conclude from this that English and Hungarian /z/ have identical voicing targets.

An interesting difference between the English and Hungarian C_2 data is the magnitude of the effect of [\pm tense] on the F_0 of the following vowel. As illustrated in figure 6.2, the difference between tense and lax obstruents is approximately 10 Hz for the Hungarian subjects as opposed to roughly 35 Hz for the English female speakers and 20 Hz for the male speakers. Note that this discrepancy between the Hungarian and English speakers cannot be attributed to differences in overall F_0 level.

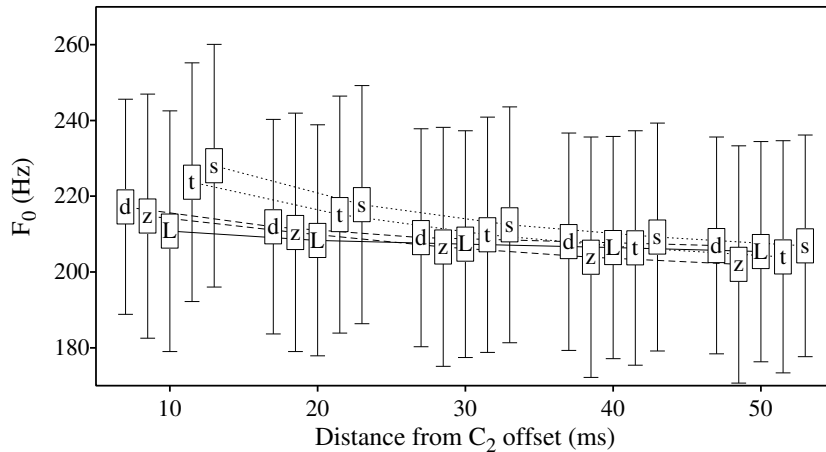


Figure 6.2: Experiment 2: F_0 (Hz) 10-50 ms into the vowel following C_2 (L = liquid). Error bars represent the mean ± 1 standard deviation.

T-tests show that the differences in duration and VOT/voicing presented in

table 6.2 are statistically significant too: $t(450) = 24.60$, $p < .001$ (plosive VOT); $t(450) = 5.48$, $p < .001$ (plosive closure duration); $t(269) = -21.06$, $p < .001$ (fricative voicing); $t(269) = 20.99$, $p < .001$ (fricative duration).

6.3.2 Voicing of C_1

Plosives Figure 6.3 represents the mean voicing of /k, g/ (closure and release) across C_2 contexts. First, the baseline pre-liquid context shows a 33 ms difference in overall voicing between /k/ (32 ms) and /g/ (65 ms), which suggests that phonetic voicing has some role in cueing the [\pm tense] distinction in Hungarian. The difference in overall voicing is significant according to a t-test: $t(135) = -15.97$, $p < .001$. Interestingly, the mean voicing *ratio* of Hungarian /g/ is higher than that of its English counterpart, at least judging by the experimental data reported in the previous chapter (.90 vs. .70). This might be interpreted as evidence that the contrast between voicing and aspirating stop systems is maintained in word-final contexts (cf. 2.2.2 above). But in light of prosodic differences between the carrier sentences used for the two experiments, such interpretations remain speculative.

Next, consider the voicing of C_1 plosives before [+tense] C_2 obstruents. Figure 6.3 indicates that C_1 voicing assimilates to a following obstruent, showing a clear reduction in the overall voicing duration of /g/ in this environment. As there is virtually no difference in voicing between /k/ and /g/ before tense /t, s/, it would seem that assimilation neutralises the voicing distinction between the two velar stops.

The patterning of C_1 voicing before the lax obstruents /d, z/ suggests that assimilation occurs in this type of context too, as there is an increase in the overall voicing of /k/ relative to the baseline value of 32 ms (by 21 and 14 ms respectively). In accordance with impressionistic descriptions, and with the predictions of a phonetic theory of RVA, the observed behaviour of Hungarian /d/ contrasts with that of its English counterpart, which patterns with the baseline context rather than with /z/ (cf. figure 5.4 above).

However, in contrast to the [+tense] C_2 contexts, assimilation in the [-tense] environments does not appear to be fully neutralising. There are residual voicing distinctions between /k/ and /g/ both before /d/ (18 ms difference) and /z/ (17 ms). This asymmetry between tense and lax C_2 environments is reminiscent of the voicing patterns of English velar stops preceding /t, s, z/ (see figure 5.4), and therefore suggest that the same mechanism might be at work in both languages.

Statistical tests bolster the impressionistic observations made in the previous paragraphs. First, a two-way ANOVA for C_1 laryngeal specification * C_2 laryngeal specification was carried out on the overall voicing values of /k/ and /g/ in pre-obstruent contexts (i.e., excluding the baseline environment). This ANOVA shows significant effects of C_1 laryngeal specification, $F(1,531) = 77.70$, $p <$

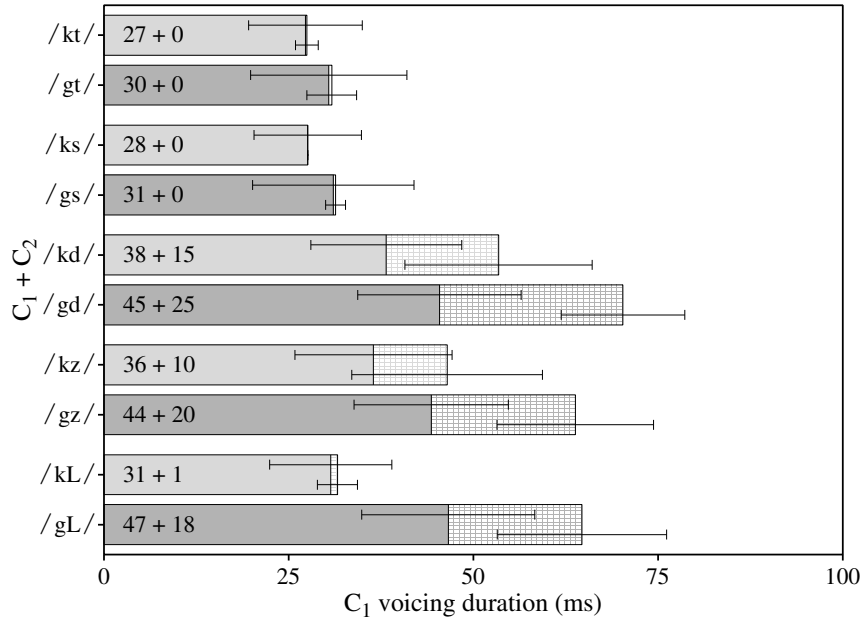


Figure 6.3: Experiment 2: Voicing of /k/ and /g/ across C₂ contexts. All measures are in ms; error bars represent the mean \pm 1 standard deviation. The diagram represents the means for voicing duration during C₁ closure and release separately: for each bar the left-hand segment indicates the temporal extent of voicing during the closure stage and the right hand segment represents the voicing duration of the release phase. Exact values for mean C₁ closure and release voicing are given in the leftmost segment for typographical reasons.

.001, C₂ laryngeal specification, $F(1,531) = 623.04$, $p < .001$, and the interaction between the two main factors C₁ Laryngeal specification * C₂ laryngeal specification, $F(1,531) = 33.16$, $p < .001$. The main effect of C₂ laryngeal specification supports the impression that regressive assimilation takes place in Hungarian obstruent clusters whilst the main effect of C₁ laryngeal specification indicates that this form of assimilation fails to completely erase underlying voicing distinctions. However, the interaction of the two main factors indicates that the main effects do not apply in equal fashion across contexts, and is most likely caused by the virtual neutralisation of voicing distinctions before tense obstruents vs. the absence of complete neutralisation in lax C₂ environments.

Fricatives Figure 6.4 depicts the mean duration of voicing in /f, ʒ/ before tense /t/, lax /d/ and baseline liquids. In the latter context, there is a marked (45 ms)

difference in voicing, which suggests that this feature plays a role in signalling the distinction between tense and lax fricatives word finally. The difference is statistically significant according to a t-test: $t(91) = -10.80$, $p < .001$.

The voicing pattern that emerges before /t/ and /d/ seems to mirror the pattern observed above for /k/ and /g/ in the same contexts. /ʒ/ (28 ms of voicing) assimilates to the tense alveolar stop to the extent that the difference in voicing with /ʃ/ (26 ms of voicing) is virtually erased. There is evidence of regressive assimilation to /d/ too, as there is a clear (24 ms) increase of voicing in /ʃ/ relative to the baseline environment, but as with /k, g/ before /d, z/, assimilation to [-tense] does not seem capable of completely erasing underlying distinctions.

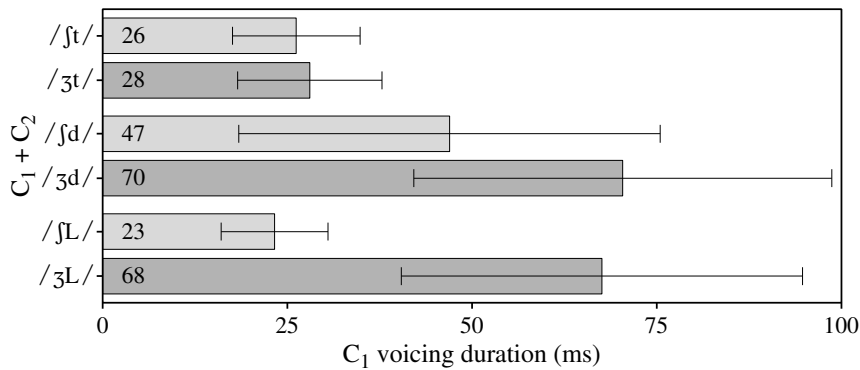


Figure 6.4: Experiment 2: Voicing of /ʃ/ and /ʒ/ across C_2 contexts. All measures are in ms; error bars represent the mean \pm 1 standard deviation.

A two-way ANOVA for C_1 laryngeal specification * C_2 laryngeal specification on the voicing values of /ʃ, ʒ/ in pre-obstruent contexts seems to bear out this apparent parallelism with the assimilatory behaviour of /k, g/ in the same set of environments. Thus, there are highly significant main effects of C_2 laryngeal specification, $F(1,184) = 107.52$, $p < .001$ (evincing regressive assimilation), C_1 laryngeal specification, $F(1,184) = 17.28$, $p < .001$ (an indication of incomplete neutralisation), and a significant interaction of C_1 laryngeal specification * C_2 laryngeal specification, $F(1,184) = 12.63$, $p < .001$ (indicating that not all combinations of C_1 and C_2 behave symmetrically). As before, the interaction seems best explained in terms of the asymmetry between [+tense] contexts, where there is virtual neutralisation of C_1 contrast, and [-tense] environments where underlying voicing distinctions between /ʃ/ and /ʒ/ is partially preserved.

6.3.3 Duration of C₁

Plosives Figure 6.5 depicts the duration of /k, g/ across the range of C₂ environments investigated by the present experiment. The bottom two bars of the diagram show how tense /k/ is marked both by a longer closure phase (71 vs. 54 ms) and a longer release burst (35 vs. 23 ms) than /g/. This behaviour is entirely consistent with the phonetic literature on the durational correlates of [\pm tense] in (medial) plosives in other languages, although this does not in itself constitute evidence that Hungarian listeners make (much) use of either of these features. The observed differences in closure phase and release burst duration between /k/ and /g/ in the baseline pre-liquid context are statistically significant according to t-tests: $t(135) = 10.08$, $p < .001$ and $t(135) = 6.42$, $p < .001$ respectively.

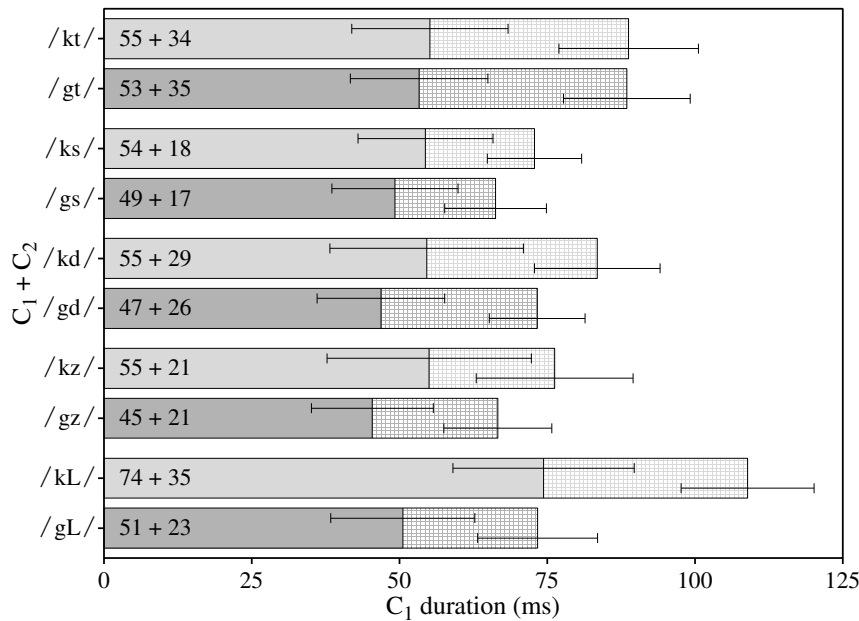


Figure 6.5: Experiment 2: Duration of /k/ and /g/ across C₂ contexts. All measures are in ms; error bars represent the mean \pm 1 standard deviation. Means for closure duration and release duration are represented separately: for each bar the left-hand segment indicates the closure duration and the right hand segment represents the duration of the release phase. Exact values for mean C₁ closure and release duration are given in the leftmost segment for typographical reasons.

When followed by another obstruent, the behaviour of the closure phase of Hungarian /k/ and /g/ is strikingly similar to that of their English counter-

parts, both in terms of pattern and absolute duration values (cf. table 5.6). The closure stage is generally shorter before an obstruent C_2 than in the baseline environment, in particular for /k/. In all four obstruent environments, there is a small positive difference in closure duration between /k/ and /g/: this difference ranges from 2 ms before /t/ to 10 ms before /z/. This positive difference suggests that the duration contrast observed in the baseline environment is incompletely neutralised when an obstruent follows.

Moreover, only the 6 ms lengthening (relative to the baseline) of /g/ before /t/ could be construed as evidence that the partial neutralisation of closure phase duration contrast between /k/ and /g/ constitutes *regressive assimilation* in the conventional sense. However, given that the assimilation of C_1 voicing discussed above is triggered by /d, s, z/ as well as by /t/, it would be difficult to attribute the lengthening of /g/ before /t/ to the same underlying mechanism.

Thus, the velar stops of Hungarian appear to exhibit the same mismatch between closure duration and voicing that was observed above for their English counterparts. Consequently, their behaviour poses the same problems to a lexical feature analysis of voicing assimilation, which predicts that voicing and segmental duration maintain their inverse behaviour under assimilation, and therefore that an increase in voicing (as a result of assimilation to a lax stop) should be accompanied by a decrease in duration. The lack of a systematic relation between C_1 closure duration and C_1 voicing is emphasised by the absence of a (statistically) significant negative correlation between the closure duration and overall voicing of /k/ and /g/ when followed by an obstruent C_2 (Pearson's $r = -.79$, $p < .07$, i.e., significant at trend level only). By contrast, in the baseline environment there is a much stronger negative correlation between closure duration and overall voicing ($r = -.45$, $p < .001$), which is an indication that in this environment the 'lexical' inverse patterning of voicing and duration does tend to hold. The relation between closure duration and voicing duration in /k, g/ across C_2 contexts is illustrated in figure 6.6.

A three-way ANOVA for C_2 laryngeal specification * C_2 manner of articulation * C_1 laryngeal specification on the C_1 closure duration data (baseline environment excluded) reveals a highly significant main effect of C_1 laryngeal specification, $F(1,531) = 30.03$, $p < .001$, and marginal effects of C_2 laryngeal specification, $F(1,531) = 5.34$, $p < .025$ and C_2 laryngeal specification * C_2 laryngeal specification, $F(1,531) = 5.51$, $p < .02$. The first of these effects indicates that on the whole, the distinction between /k/ and /g/ is maintained in terms of C_1 closure duration, at least in speech production. It seems likely that the latter two effects are caused by the 'assimilatory' behaviour of /g/ before /t/, but as argued above, there is little evidence that the mechanism responsible also drives assimilation of C_1 voicing.

Finally, the duration of the *release stage* of /k, g/ does appear to show the

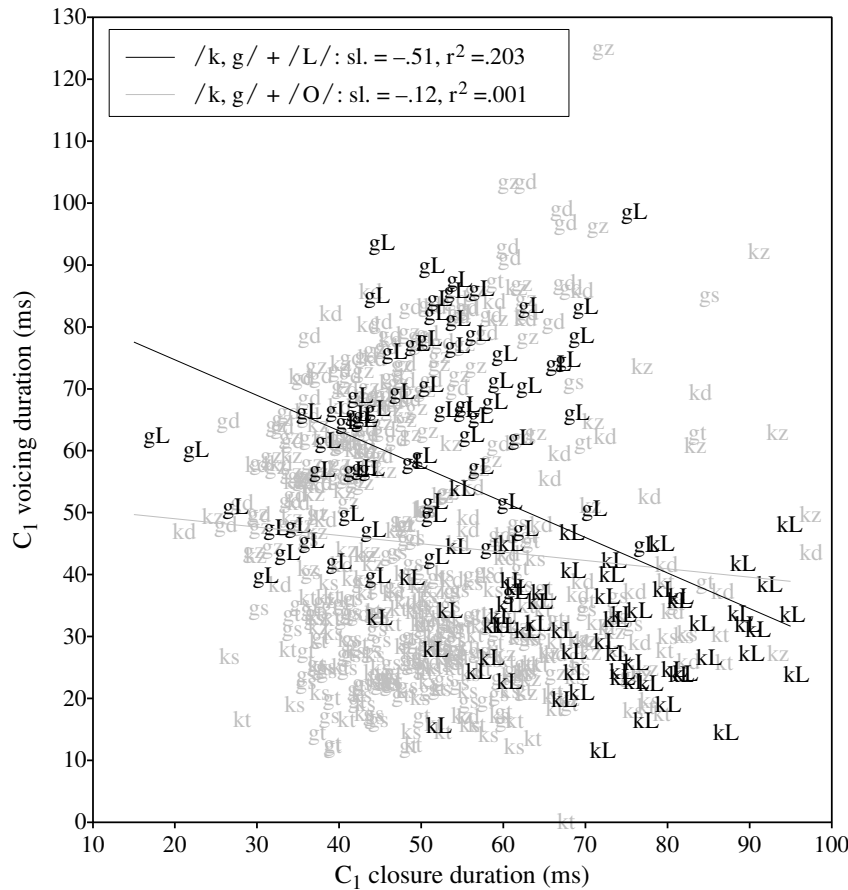


Figure 6.6: Experiment 2: scatter plot of C_1 voicing against C_1 closure duration. C_1 closure duration and C_1 overall voicing values (both in ms) for /k, g/ in obstruent clusters (in grey) and before a liquid (in black) with regression lines.

effects of assimilation to a following stop: relative to the baseline context, the duration of the release of /g/ increases by 12 ms before /t/, and there is a 6 ms decrease in the length of the release of /k/ when it is followed by lax /d/ (see figure 6.5; as in the discussion of the English data above I will exclude sequences with a C_2 fricative from the analysis of release duration because it is probable that the relevant values are distorted by the overlap between release and fricative noise). A two-way ANOVA for C_1 laryngeal specification* C_2 laryngeal specification on the release duration values in pre-obstruent environments (/t/ and /d/ only) shows that assimilation neutralises the underlying distinction between /k/ and /g/: there is a highly significant effect of C_2 laryngeal specifica-

tion, $F(1,260) = 27.60$, $p < .001$, but not of C_1 laryngeal specification, $F(1,260) = .123$, not significant, or the interaction between C_1 laryngeal specification * C_2 laryngeal specification, $F(1,260) = 2.40$, not significant.

Thus, there is an apparent contradiction in the behaviour of the closure and release stages of velar stops preceding obstruents. However, there is a natural account of the release duration pattern that removes this contradiction. I will discuss this account as part of the analysis of fricative C_1 duration immediately below.

Fricatives The durational behaviour of /ʒ, ʒ/ when followed by an alveolar stop parallels that of the release stage of /k, g/. There is an increase (19 ms) in the length of /ʒ/ before tense /t/ and an even clearer decrease (34 ms) in the duration of /ʒ/ before /d/. Neither of these two environments preserves the baseline pattern, which exhibits the expected positive duration difference between the tense and lax postalveolar fricatives (30 ms): preceding /d/ this difference is reduced to a mere 3 ms whilst before /t/ it is reversed (by 9 ms). A t-test shows that the baseline contrast is statistically significant: $t(91) = 7.48$, $p < .001$, whilst a two-way ANOVA for C_1 laryngeal specification * C_2 laryngeal specification on the duration values in pre-obstruent contexts reveals a highly significant effect of C_2 Laryngeal specification, $F(1,184) = 46.74$, $p < .001$, but no effect of C_1 laryngeal specification, $F(1,184) = .938$, not significant, and only a very weak interaction of C_1 laryngeal specification * C_2 laryngeal specification, $F(1,184) = 4.92$, $p > .03$. The first of these supports the impression that fricative C_1 duration behaves in an assimilatory fashion, whilst the absence of a main effect of C_2 laryngeal specification indicates that this assimilation neutralises the distinction between /ʒ/ and /ʒ/ with respect to this feature. The 'reversed' patterning of duration before /t/ is likely to be the predominant cause of the interaction between the two main factors, and can therefore not be treated as a sign of incomplete neutralisation.

It appears, therefore, that the duration of the release stage of velar stops and the overall duration of C_1 fricatives pattern identically in assimilating to a following stop in a neutralising fashion. This behaviour might be interpreted in support of a phonological feature analysis of Hungarian RVA. However, this assimilatory behaviour is equally explicable in terms of mechanical linkage between the production of voicing and the generation of turbulence noise in the oral tract. In chapter 2 I pointed out that the production of frication noise (and most of the oral release of the C_1 velar stops is just that) depends on a high transglottal airflow and hence requires some degree of glottal abduction. The production of vocal fold vibration on the other hand requires glottal *adduction*. This means that when voicing gestures are superimposed on a vocal tract configuration suitable for the production of a fricative, the result is a shortening of

the interval of frication noise: recall how [Stevens et al. \(1992\)](#) invoke this mechanism to account for the fact that English lenis fricatives have the same duration as their fortis counterparts if measured in terms of F_1 transitions but that they nevertheless have shorter frication intervals.

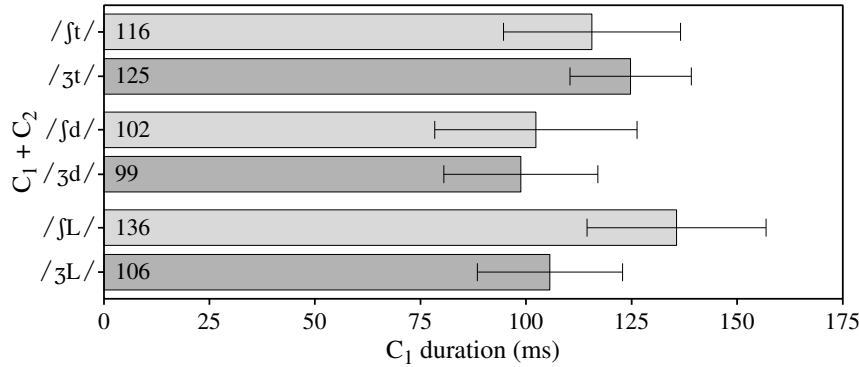


Figure 6.7: Experiment 2: Duration of /ʃ/ and /ʒ/ across C_2 contexts. All measures are in ms; error bars represent the mean \pm 1 standard deviation.

The same mechanism can be invoked to capture the duration of C_1 fricatives and release noise: the only difference is that coarticulation rather than an underlying [-tense] specification is the source of the superimposed voicing gestures. I believe that this account should be favoured over a lexical feature analysis because the latter does not resolve the closure duration and voicing observations discussed above.

6.3.4 Duration of preceding vowels

The following paragraphs discuss the behaviour of lexically long vowels only. Short vowels are excluded from the discussion for two reasons. First, factoring in the effects of lexical vowel length would have complicated the presentation and analysis of the results in an unnecessary manner; second, the short vowel data is rather noisy, in particular due to the behaviour of a single stimulus item, /jog/, *law*, *right*, which tends to have a much shorter vowel than any of the remaining short vowel contexts, and consequently skews the results for $_ /g/X$ contexts. Taking on board the effects of this overly short vowel would have further complicated the discussion below.

Plosives Figure 6.8 represents the duration of lexically long vowels across plosive C_1 and C_2 environments. In the baseline pre-liquid environment vowel du-

ration patterns in a way that suggests that, as many other languages, Hungarian utilises preceding vowel duration as a cue to the [\pm tense] distinction in word final obstruents. The expected negative difference between /k/ and /g/ materialises, is of roughly the same magnitude as the value observed for English in experiment 1 (25 ms), and is statistically significant according to a t-test: $t(68) = -3.52$, $p < .005$.

But there is a marked difference between English and Hungarian with regard to the behaviour of vowels before obstruent clusters. Recall that in English, the vowel length distinction between /k/ and /g/ is virtually unaffected by the nature of C_2 . In Hungarian on the other hand, the vowel length distinction is reduced or erased when C_2 is an obstruent. In the data summarised in figure 6.8 the phenomenon seems most marked before /t/ where for all practical purposes there is complete neutralisation of the contrast. —/z/, which displays a 14 ms difference in vowel length, represents the other end of the scale.

A two-way ANOVA for C_1 laryngeal specification * C_2 laryngeal specification on the vowel length data summarised in figure 6.8 fails to detect any effects of C_1 laryngeal specification, $F(1,269) = 3.04$, not significant, C_2 laryngeal specification, $F(1,269) = 2.70$, not significant, or C_1 laryngeal specification * C_2 laryngeal specification, $F(1,269) = .784$, not significant.

This is an interesting result, since the absence of an effect of C_1 laryngeal specification suggests that vowel length distinctions tend to neutralise when velar plosives are followed by another obstruent, whilst the absence of an effect of C_2 laryngeal specification indicates that C_2 obstruents are also unable to trigger any consistent length effects, and consequently that the neutralisation process is not *assimilatory* in the conventional sense. In other words, it appears that before obstruent clusters vowel length cues neither the underlying contrast between /k/ and /g/, nor the laryngeal specification of the obstruents that follow them.

Whilst this observation might be problematic for phonological feature-spreading accounts of RVA, it is certainly not predicted by a coarticulatory account of voicing assimilation either. In chapter 4 I argued at length that the coarticulation of articulatory gestures realising [\pm tense] cannot have an effect on the duration of a preceding vowel, and this means that the only possible conclusion at this point is that Hungarian RVA is not, or at least not solely, based on coarticulation.

Fricatives The patterning of vowel length before clusters starting with a fricative provides an interesting final twist to this argument, as there is evidence that before such clusters the vowel length contrast is retained. Note, first of all that in the baseline environment the vowel length contrast between /f/ and /ʒ/ is more pronounced (at 42 ms) than that between /k/ and /g/ in the same context (25 ms). Unsurprisingly therefore, the difference is statistically significant

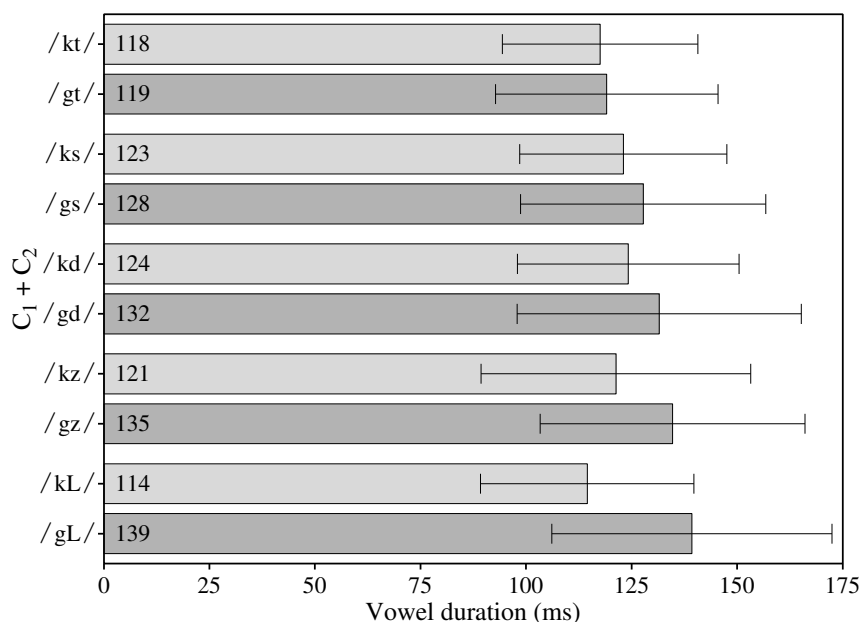


Figure 6.8: Experiment 2: Duration of vowels preceding /k/ and /g/ across C₂ contexts (only lexically long vowels included). All measures are in ms; error bars represent the mean \pm 1 standard deviation.

according to a t-test: $t(45) = -4.81$, $p < .001$.

However, whereas the vowel length contrast between the velar stops is (near-)neutralised before /t, d, s, z/ it is largely retained before /ʃ, ʒ/ + /t, d/. The increased in vowel length before /ʃ/ + /d/ may reflect some degree of assimilation, but if vowel length indeed assimilates to C₂ the effect is far too weak to erase the distinction expressing the lexical contrast between tense and lax postalveolar fricatives.

This impression is borne out by a two-way ANOVA for C₁ laryngeal specification * C₂ laryngeal specification on the vowel length values found in pre-obstruent contexts. This ANOVA reveals a (highly) significant effect of C₁ laryngeal specification only, $F(1,90) = 43.42$, $p < .001$, whilst the effect of C₂ laryngeal specification, $F(1,90) = 3.05$, can only be regarded as a trend ($p > .085$). The effect of the interaction of C₁ laryngeal specification and C₂ laryngeal specification, $F(1,90) = 1.31$, is not significant.

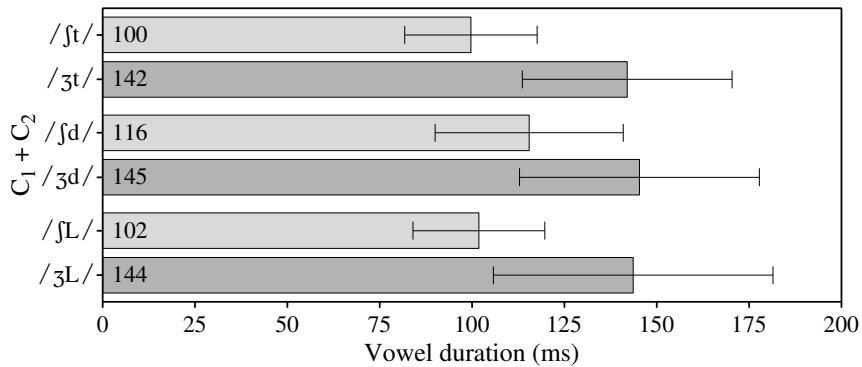


Figure 6.9: Experiment 2: Duration of vowels preceding /k/ and /g/ across C_2 contexts (only lexically long vowels included). All measures are in ms; error bars represent the mean \pm 1 standard deviation.

6.4 General discussion and conclusions

Two things stand out in the results of experiment 2. The first is that Hungarian RVA leads to incomplete neutralisation of [tense] distinctions in target sounds. For example, there are residual traces of the underlying contrasts between /k/ and /g/, and /ʃ/ and /ʒ/ in terms of C_1 voicing. It is interesting that the lack of phonetic voicing neutralisation should occur before the lax obstruents /d, z/, which mirrors the findings with regard to English above. The vowel length contrast between /ʒ/ and /ʃ/ is also preserved in the presence of a following obstruent. In addition, the behaviour of Hungarian /k, g/ is highly similar to that of their English counterparts in that the closure stage of the tense plosive shortens before another obstruent (regardless of its laryngeal specification), whilst there is some indication that the patterning of closure stage duration maintains a faint trace of the underlying [tense] contrast.

Considered in isolation, the similarities of these observations to the English results reported in the previous chapter, suggest a similar conclusion to the one drawn above with regard to the nature of RVA in English. However, this conclusion is contradicted by the second striking fact about the results of experiment 2, viz. that the vowel length distinction between /k, g/ is (near-)neutralised in the presence of a following obstruent. As argued at length in section 4.1.2 above, a purely articulatory form of RVA should leave vowel duration unaffected, and so it would seem that Hungarian RVA is not, or not purely, driven by coarticulation.

This raises a number of questions that must remain largely unanswered here. First and foremost is the question what process is responsible for the neutrali-

sation of vowel length distinctions before velar stop + obstruent sequences. An obvious hypothesis is that Hungarian RVA is a proper phonological process and therefore reflected by all phonetic correlates of [tense]. Under this hypothesis, the incomplete neutralisation effect would be a byproduct of the sort of lexical interference briefly touched on in section 3.2.2 rather than of the coarticulatory nature of the rule. In other words, the Hungarian data would represent “an attempt at neutralisation”, to borrow a phrase from Jim Scobbie (p.c.).

This account might be extended along the lines proposed by Myers (2002) to include the idea that the Hungarian version of RVA is a phonologised version of the English version, caused by the effects of the latter on the perceptibility of plosives in the relevant contexts.

Plausible and attractive as this hypothesis may sound, it raises a number of further issues. One is why Hungarian (part-)phonologised the coarticulatory process found in English, whilst the latter language failed to follow this line of development itself. It is tempting to speculate that the symmetry of (fortis as well as) lenis obstruents (both /d/ and /z/) and/or differences in the role of vowel length in cueing [tense] have played a role here.

A second issue is why the present results show fricatives to be more resistant to neutralisation than plosives (assuming that this is not merely an artefact of the chosen stimulus items). One possible hypothesis in this area is that the cues to [\pm tense] in fricatives are somehow less vulnerable to the effects of coarticulatory RVA than stops, perhaps because a greater role of vowel length in cueing the contrast (note that there is a greater degree of vowel shortening before \int than before /k/ in the baseline context.)

However, the data presented here does not allow for these issues to be resolved, and therefore I will leave them to future research.