DIFFERENTIAL WEIGHTING OF PHONETIC PROPERTIES IN CROSS-DIALECTAL PERCEPTION

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Abstract

Against the background of differences in the use of fortis and lenis plosive symbols for cognate words in Rhenish-Franconian and Moselle-Fanconian dialect descriptions, a production analysis was carried out on the fortis and lenis plosives in 4 German and 6 germanophone Lorraine dialect communities. The results indicate systematic production differences which could underlie the divergent symbolic representations. To test whether these production differences also reflect differing perceptual prototypes, two series of perception tests were carried out in each community in which manipulated stimulus words from each of the French or from each of the German communities were offered for identification. Systematic shifts in identification patterns across regions corresponding to the differences found in production indicate differences in perception strategies, suggesting that the frequent cross-dialect communication must rest on an approximation process. It is argued that this cross-dialect approximation is merely a special case of idiolect approximation, which is the basis of all speech communication.

1. Introduction

The description of dialects rests on the assumption that differences between dialects are systematic, i.e., they are part of the sound systems serving spoken-language communication in the particular areas. Behind the differences of related dialects there must lie a process of change which is of interest to diachronic studies. Such processes of change, it is assumed (Ohala, 1989, 1993) can be the result of the reinterpretation of certain aspects of one group's pronunciation by members of another group, resulting in a new articulatory patterning. The internal cohesion and relative separation of the second group from the first, either in time, as from one generation to another, or

Festschrift for Max Mangold, Phonus 6, IPUS, Saarbrücken, 2002, 191-220

space, as with regional dialect communities, allows the new pattern to become established. But it is also important to remember that communication can continue across the systemic divisions arising as a result of such processes. Since speech communication is the en- and decoding of a message into and from syntactically structured word strings, it implies that the speaker's speech patterns are matched with the hearer's internal representation of the words produced as represented in traditional speech chain schemata. This means that speech communication is always, in formal terms, an *approximation of idiolects*.

The process of approximation is obvious in second-language learning. It is what underlies (among other things) the foreign-accent phenomenon, which in learning-psychology terms is seen as the result of "interference". However, the phenomenon is not normally considered *within* a language, despite the considerable differences that exist between regional and social variants. Within dialects, approximation is much closer than across them, and the "reinterpretation" process goes unnoticed, presumably because the underlying systems correspond[1]

This study is an attempt to uncover some dimensions of the approximation between related dialect regions in connection with plosive production and perception. The hypothesis behind the experiments reported is that perceptual strategies will differ between the regions in a way that is related to the differing manner in which the plosives are produced.

2. Moselle- and Rhenish-Franconian Plosives

In the Moselle-Franconian (MF) and Rhenish-Franconian (RhF) regions of the Saarland and the N.W. Palatinate in Southwestern Germany, and of Lorraine in Eastern France (see figure 1), plosives in initial plosive-liquid clusters have been systematically transcribed by dialectologists using the fortis plosive in one region and the lenis plosive in the other (Braun & Mangold, 1984; Pützer, 1993; Conrath & Mangold, 1994; Peetz & Pützer, 1995; Peetz & Pützer, 2000):

[1] The function of an abstract underlying system , to which a variety of surface forms can correspond was an important aspect of Uldall's glossemetric theory, and is discussed in some detail with regard to phonology in Fudge, 1972.

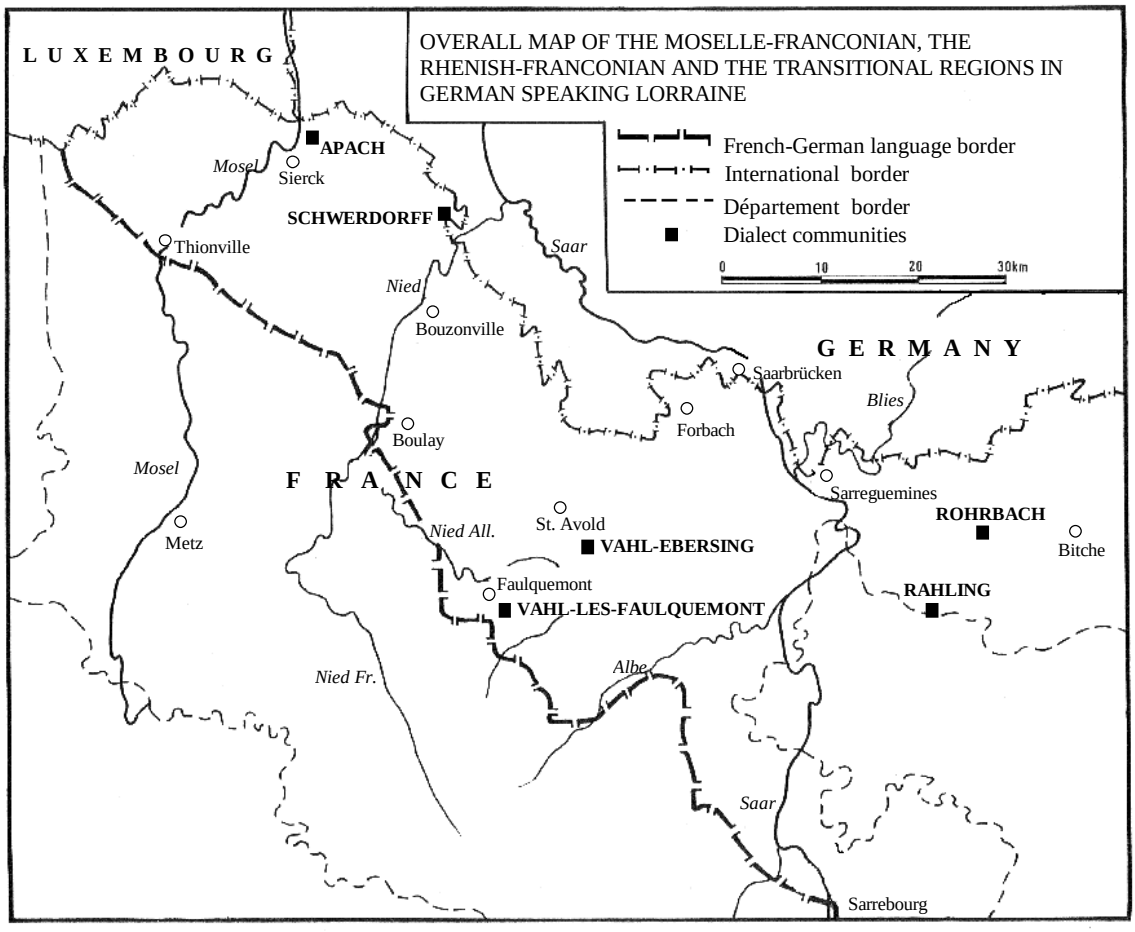

Figure 1. Overall map of the Moselle-Franconian, the Rhenish-Franconian and the transitional regions in German speaking Lorraine.

MF(Beuren/Besseringen)[2]	RhF(SB/Großrosseln)	Standard G.	Engl.
/ ᵛprant /	/ 'brɔnd /	Brand	fire
/ 'trum /	/ 'drʊməl/	Trommel	drum
/ 'klo:r /	/ glɔ:r /	klar	clear

This alternation is established despite the existence of a fortis-lenis opposition in both regions.

[2] The accents ' and ᵛ indicate the tonal accents TA 1 ("Stoßton") and TA 2 ("Schleifton") that caracterize some words (and differentiate some word pairs) in the Moselle-Franconian region.

MF(Beuren/Besseringen)

/ 'paus / (Pause; Engl. pause) - / 'baus / (Beule; Engl. boil/dent)

/ 'taŋk/ (Tank; Engl. tank) - /'daŋk/ (Dank; Engl. thanks)

/ 'ko:r / (Korn; Engl. corn) - / 'go:r / (Garn; Engl. thread)

RhF(SB/Großrosseln)

/pɛ:r / (Pferd; Engl. horse) - / bɛ:r / (Bär; Engl. bear)

/taŋg / (Tank; Engl. tank) - /daŋg / (Dank; Engl. thanks)

/ ' kʊmər/ (Kummer; Engl. worry) - / 'gʊmər / (Gurke; Engl. gherkin/cucumber)

The same sort of alternation is found on the French side of the border in Lorraine, though, interestingly and so far inexplicably, the regional distribution is the reverse of that found on the German side of the border, with the lenis representation established in the N.W. Moselle-Franconian dialects while the fortis is found in the S.E. Rhenish- Franconian area (Phillip, Bothorel & Levieuge, 1977).

MF(Apach/Schwerdorff)	RhF(Rahling/Rohrbach)	Standard G.	Engl.
/ brɪl /	/ prɪl /	Brille	spectacles
/ drɔ:n /	/ trɔ:n /	tragen	carry/wear
/ glɔ:r /	/ klɔ:r /	klar	clear

This divergent representation of the plosives not involved in the fortis-lenis distinction implies a different phonetic basis, which, according to the initial hypothesis, should be manifest both in production data and in perceptual reactions. The aim of this study was to identify differences in that phonetic basis.

The phonetic structure of the fortis-lenis opposition is known to be complex in languages with Germanic roots (Slis & Cohen, 1969; Lisker, 1978; Kohler, 1979). Consequently, the scope for exploiting one aspect rather than another without endangering cross-dialectal "approximation" processes in communication is extensive. 'Plosive-intrinsic' properties of interest are closure duration, closure voicing, stop release, and degree of aspiration. Differences in vowel duration preceding fortis and lenis, and in the vocalic transitions into and out of the stop closure we call 'plosive-extrinsic' properties.

3. Plosive production experiment

3.1. Language material

Ten speakers, one each from 10 small towns or villages spoke ten tokens of bilabial, alveolar and velar fortis-lenis initial plosive minimal pairs appropriate to the particular dialect (see Appendix 2). The communities in Lorraine were those in which a wider range of speakers had been investigated in the course of a cross-border comparison of Moselle- and Rhenish- Franconian dialect features[3]. Two (Apach and Schwerdorff) are located in the Northwest MF region, two (Rahling and Rohrbach) in the Southeast RhF region, and two (Vahl-Ebersing and Vahl-lès-Faulquemont) in the transitional region (TR) between them, which is known to exhibit a mixture of MF and RhF. The four German communities were Beuren and Besseringen in the MF regions of North Saarland and the Northwest Palatinate, and Saarbrücken and Großrosseln in the RhF[4] region of the Southern Saarland, respectively.

The ten tokens of the minimal pairs were recorded in two separate randomised series of five, the words being spoken in carrier sentences equivalent to the High German "Ich habe immer __ gesagt" (I have always said __)

Eg. RhF: /ix xɔn 'imər pɛ:r gə 'za:d/

/ix xɔn 'imər bɛ:r gə 'za:d/

The recordings were digitized at a 16kHz sampling rate and the stop closure duration (Cldur), the periodicity during closure (Clv), and the duration between stop release and voicing onset for the following vowel (VOT) were measured using the Kay CSL waveform and spectrographic display facilities.

3.2. Production results

Table I and table II give the average values for the dialect regions. Values for the individual speakers from the ten communities are given in Appendix 1.

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[3] The Project "Germanophone Dialekte Lothringens" was funded by the German Research Council (Ba 737/3-1/2) from May 1993.

[4] Großrosseln is usually considered to belong to the transitional region, showing features of both the RhF and the MF dialect areas.

Table I. Regional average durations in ms for Stop Closure (Cldur), Closure voicing (Clv) and Voice onset time (VOT) on the German side.

		Fortis			**Lenis**	
	p	t	k	b	d	g
German MF speakers						
Cldur	142	148	147	138	122	130
Clv	11	7	7	32	16	57
VOT	38	47	68	9	11	23
German RhF speakers						
Cldur	116	115	99	133	116	119
Clv	17	14	12	23	18	18
VOT	39	48	66	9	14	17

Table II. Regional average durations in ms for Stop Closure (Cldur), Closure voicing (Clv) and Voice onset time (VOT) on the French side.

		Fortis			**Lenis**	
	p	t	k	b	d	g
French MF speakers						
Cldur	99	87	71	85	78	72
Clv	22	7	5	81	63	58
VOT	47	53	57	11	14	17
French TR speakers						
Cldur	172	171	164	148	167	119
Clv	24	17	18	113	79	92
VOT	47	44	53	8	12	17
French RhF speakers						
Cldur	231	234	247	180	240	317
Clv	36	33	23	39	44	30
VOT	23	37	65	12	14	22

The three dependent variables, closure duration, closure voicing, and burst duration (VOT) were tested for the effects of the independent variables Fortis/Lenis, Regional Group, and Individual Speaker in three three-way ANOVAS for the German and the French speakers.

Table III. Results of ANOVA for the productions by Saarland/Palatinate speakers.

	F	**DF**	**Sig. level**
Closure Duration			
Fortis/Lenis	0.56	1	0.454
Regional Gr.	71.20	1	< 0.001
Speaker	2.03	**2**	0.133
Sig. Interactions			
F/L x Reg. Gr.	30.80.	1	< 0.001
Closure Voicing			
Fortis/Lenis	50.12	1	< 0.001
Regional Gr.	4.42	1	0.037
Speaker	41.54	**2**	< 0.001
Sig. Interactions			
F/L x Reg. Gr.	22.58	1	< 0.001
F/L x Speaker	25.84	2	< 0.001
Burst Duration			
Fortis/Lenis	622.59	1	< 0.001
Regional Gr.	0.14	1	0.711
Speaker	8.32	**2**	< 0.001
Sig. Interactions			
F/L x Speaker	13.04	2	< 0.001

Table III summarises the ANOVA results for the Saarland/Palatinate speakers. This shows that closure durations and closure voicing are systematically different across the two dialect regions, and importantly, the regional groups differ in the way they employ these parameters for the Fortis/Lenis distinction. With regard to Closure

Duration, which does not differ significantly as a function of the Fortis/Lenis category, the interaction stems from the unusual reversal of the Fortis/Lenis relationship from one region to the other - the "Lenis" closures are systematically longer for the RhF speakers, a phenomenon which has not been reported previously in the literature. With regard to closure voicing, where the MF speakers manifest longer voicing than the RhF speakers, there is also a strong individual difference within the regional groups. Individual speaker differences are also revealed in the F/L x Speaker interaction of the Burst Duration effect. The Lorraine speakers' test results are summarised in table IV.

Table IV. Results of ANOVA for the productions by Lorraine speakers.

	F	**DF**	**Sig. level**
Closure Duration			
Fortis/Lenis	5.43	1	0.021
Regional Gr.	121.62	1	< 0.001
Speaker	11.46	2	< 0.001
No Sig. Interactions			
Closure Voicing			
Fortis/Lenis	323.60	1	< 0.001
Regional Gr.	23.90	**1**	0.037
Speaker	0.26	**2**	0.770
Sig. Interactions			
F/L x Regional Gr.	6.75	2	0.01
Burst Duration			
Fortis/Lenis	615.20	1	< 0.001
Regional Gr.	0.42	**1**	0.952
Speaker	17.03	**2**	< 0.001
Sig. Interactions			
F/L x Speaker	11.31	2	< 0.001

In contrast to the German speakers, closure duration does differentiate the Fortis/Lenis categories for the Lorraine speakers. However, the very strong regional

and speaker effects are the product of extremely long values for the TR. and (particularly) the RhF speakers, who regularly paused to give the test word the emphasis they must have thought it deserved. Also in contrast to the German speakers, Closure Voicing makes a very strong contribution to Fortis/Lenis differentiation in Lorraine, and there is also a systematic regional effect, with the RhF speakers not exploiting the voicing.

The production differences between the regions and between Germany and France were sufficient to hypothesise some differences in perceptual strategies, if the hypothesis of inter-dialectal reinterpretation made at the outset is to be accepted. The prime candidate is closure voicing, which should be of importance to French MF and TR listeners but not to RhF listeners (on either side of the national border). Its importance to German MF listeners is less easy to predict. The lack of any prime regional voicing effect in German production makes it appear doubtful, though the regional group x F/L interaction suggests the possibility.

4. Perception experiment I

A perception experiment was carried out to ascertain whether there was any difference in the way listeners from each of the communities processed the properties known to influence the impression of fortis and lenis plosives.

4.1. Stimulus material

It was decided to offer the words for identification in the same carrier sentence context in which they were spoken. So, to maintain as natural a stimulus structure as possible, synthetic stimuli were not employed, and only time-domain manipulation was performed to elicit the differentiated responses needed to address the hypothesis. One representative minimal pair token was selected for each speaker for each place of articulation, giving 36 base stimuli from the French side of the border, and 24 base stimuli from the German side.

These base stimuli were manipulated in the following way:

1. Each base stimulus was modified in three steps with regard to the stop-release component (VOT). It was combined with the appropriate full fortis stop release, the fortis stop release reduced in duration to the duration of the corresponding lenis

release, and a lenis release[5] . This resulted in 108 Lorraine and 72 German stimulus variants.

2. Each of these combinations was offered with a carrier sentence (preceding and following) context taken from the original utterances with Lenis and a Fortis stops (producing a doubling of the stimulus number to 216 and 144 stimuli, respectively)

These were presented in randomised order, to 6 listeners in each of the communities (12 per regional group) for identification as one of the words with either the fortis or the lenis plosive. Thus, each stimulus was judged by 36 listeners in Lorraine and 24 listeners in the Saarland/Palatinate.

4.2. Results of perception experiment 1

Figure 2 shows the overall percent fortis judgments (to the nearest percentage point) by the listeners of different regional origin:

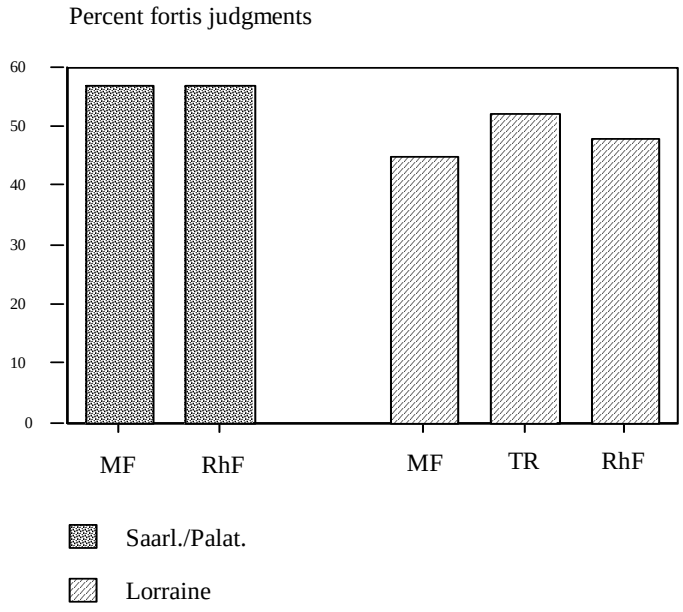

Figure 2. Fortis judgments by listeners of different regional origin.

[5] In the case of the German stimuli, this was a low-intensity part of the fortis release with the duration of the lenis release. For the French stimuli, it was the actual lenis release.

Percentages across the national border cannot be compared directly, since the stimuli offered for judgment are different. However, there is clearly more variation between regional groups on the French than on the German side; both German regional groups make 57% fortis judgments, while the Lorraine groups vary between 45% and 52%.

Figures 3a-3c show the influence of a) stop release, b) stop closure and c) fortis and lenis context on the percentage of fortis judgments.

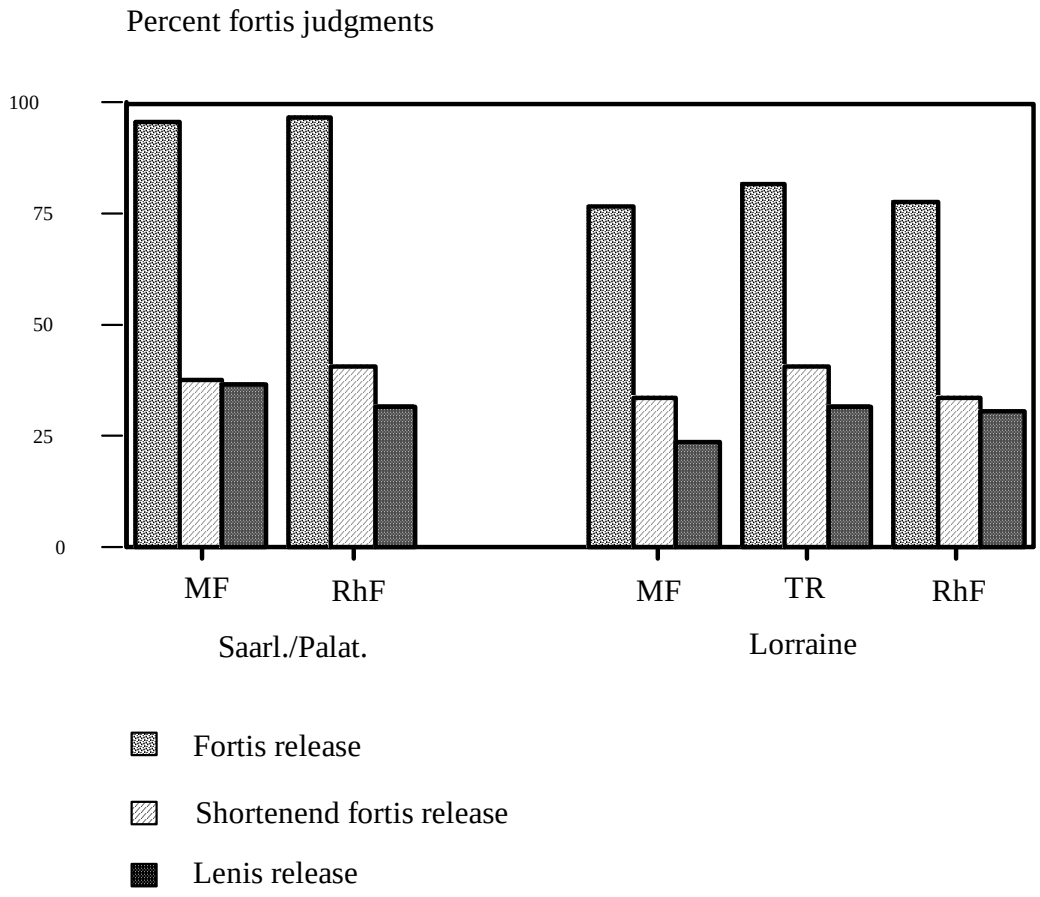

Figure 3a. Influence of stop release.

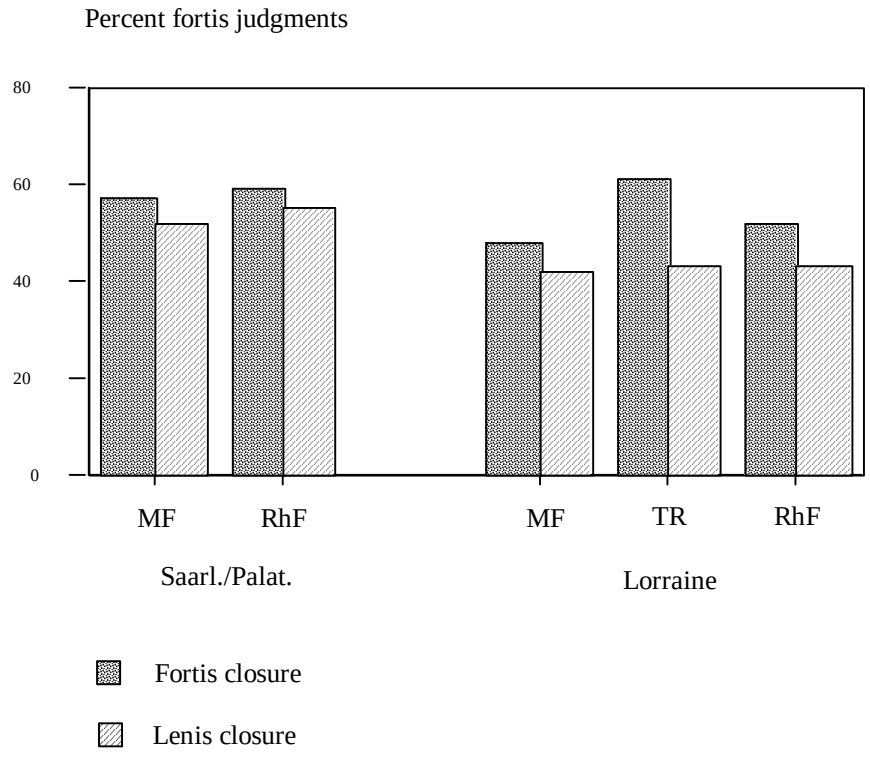

Figure 3b. Influence of stop closure.

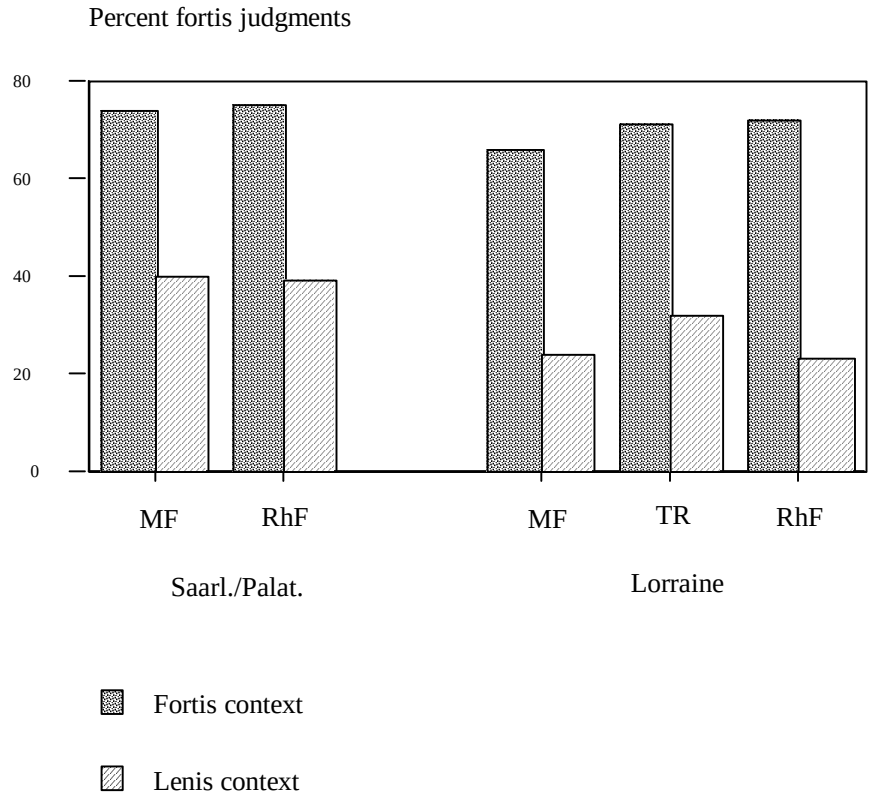

Figure 3c. Influence of fortis/lenis context.

These results can be summarised as follows:

i) The effect of the manipulated stimulus components is strongest for the stop release (VOT) and weakest for the stop closure for all listener groups, on both sides of the national border.

ii) The range of these effects is stronger for the German listener groups than for the French listeners. The stop-release factor appears more important and the stop closure less important to the German listeners than to the French.

iii) There is more difference overall between the three Lorraine listener groups than between the two Saarland/Palatinate groups.

Since these results are the regional listener groups' judgment of all stimuli, the effects are not differentiated for the differences in the acoustic structure of the stimuli as shown in production analysis. Figure 4 shows the listener groups judgments as related to the origin of the stimuli.

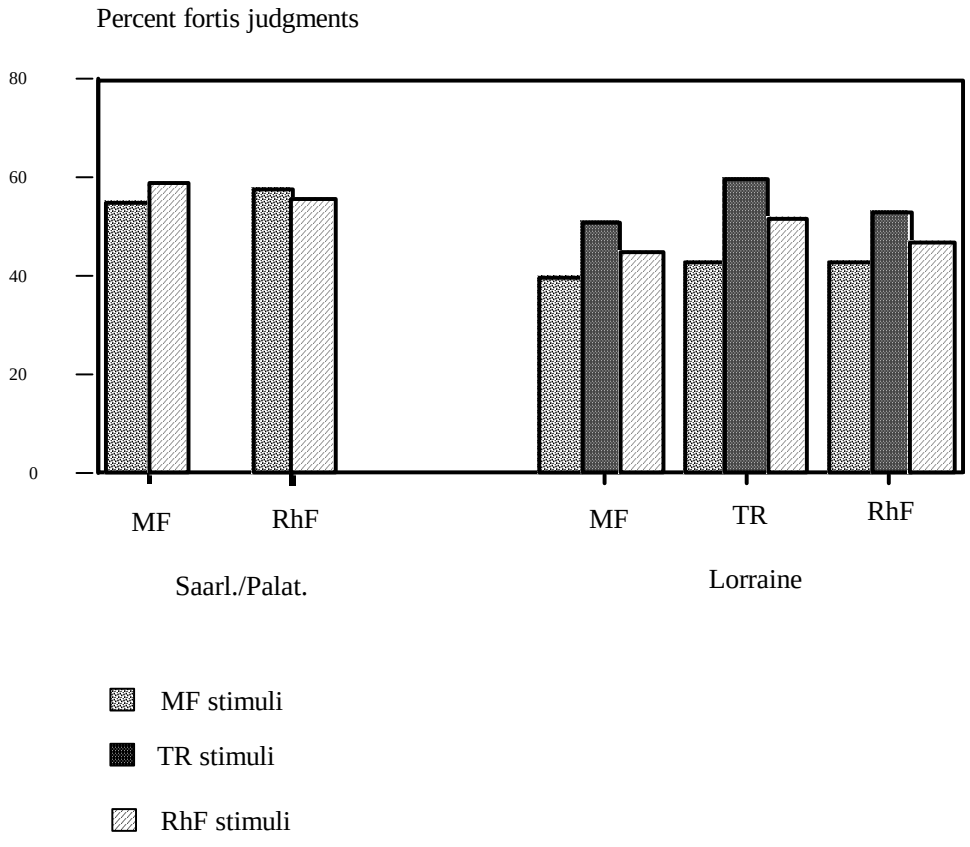

Figure 4. Percent fortis judgments for the German and French listener groups as a function of the origin of the stimuli.

For the Saarland/Palatinate listeners, visual inspection shows a small reversal of the proportion of fortis judgments made by the regional listener groups for MF and RhF stimuli; i.e., MF listeners appear to hear more RhF stimuli as fortis, and RhF listeners hear more MF stimuli as fortis. This is not predictable from the differences in the production data. With the Lorraine listeners, all three regional listener-groups show the same pattern of differential fortis judgments as a function of stimulus origin: TR stimuli are heard as more fortis, and MF stimuli are heard as more lenis, with the RhF stimuli lying between them. This corresponds to some degree with the differences in closure duration and closure voicing found in the production data.

Testing for listener-group effects in a five way ANOVA (Listener group x stop release x carrier-sentence context x stimulus origin x fortis-lenis closure), all main effects were shown to be significant for the Lorraine listeners (see table Va). The significant effect for the factor listener-group is of particular importance, revealing as it does, differing perception strategies. The interactions between the listener groups and the other independent variables is also of interest, although the underlying phonetic properties are not immediately interpretable. The interaction with the fortis-lenis closure might indicate different sensitivities either to closure duration or to closure voicing, since these properties were not separated. The significant interaction between the listener group and carrier-sentence context also cannot be interpreted in terms of production parameters.

Table Va. ANOVA results for Lorraine listener groups.

	F	**DF**	**Sig. level**
Closure Duration			
Fortis/Lenis	5.43	1	0.021
Regional Gr.	121.62	1	< 0.001
Speaker	11.46	2	< 0.001
No Sig. Interactions			
Closure Voicing			
Fortis/Lenis	323.60	1	< 0.001
Regional Gr.	23.90	**1**	0.037
Speaker	0.26	**2**	0.770
Sig. Interactions			
F/L x Regional Gr.	6.75	2	0.01

Burst Duration			
Fortis/Lenis	615.20	1	< 0.001
Regional Gr.	0.42	**1**	0.952
Speaker	17.03	**2**	< 0.001
Sig. Interactions			
F/L x Speaker	11.31	2	< 0.001

Table Vb. ANOVA results for Saarland/Palatinate listener groups.

	F	**DF**	**Sign. Level**
Source of Variation			
Listener group	0.00	1	0.972
Context	473.86	1	< 0.001
Stop release	601.82	2	< 0.001
Stimulus origin	0.36	1	0.549
Closure F/L	19.70	1	< 0.001
Sig. Interactions			
List. gr. x stim orig	4.10	1	0.049
List. gr. x closure	4.10	1	0.049

For the German listeners, the main effects of carrier sentence-context closure and stop release were all highly significant, but there was no main effect of regional listener group. However, the reversal in the proportion of fortis judgments as a function of stimulus origin, is reflected in a weakly significant interaction, listener group x stimulus origin.. There is also a weak interaction listener group x stop closure (see Table Vb).

5. Perception experiment II

The results of the production analysis showed systematic differences for the Lorraine speakers between MF and RhF, and those of the first perception experiment revealed differences in their perceptual judgments. However, the perceptual differences stem from the sentence context rather than from stop-inherent properties, a factor which was varied in the definition of the test stimuli, but which had not been the object of production analysis.

Since, also, the structure of the stimuli used in the experiment was basically determined by the values found in the different natural productions, there had been no systematic separation of stop-closure duration and stop-closure voicing. Both of these properties had shown systematic variation across the regions in the production data (see Appendix 1). A second experiment was therefore performed with controlled stimulus variation, in which production differences were compensated for as much as possible without losing the natural production basis of the stimuli.

5.1. Stimulus material

Representative base stimuli were selected from each of the dialect regions as with experiment 1. In view of the greater number of manipulation dimensions and steps envisaged, it was not practicable to take examples of all three place-of-articulation pairs from each region.

Therefore in the German regions, the stimuli were selected as follows:

RhF	MF
/ pɛ:r / (horse) - / bɛ:r / (bear)	/ 'taŋk / (tank) - / 'daŋk / (thanks)
/ taŋg / (tank) - / daŋg / (thanks)	/ 'ko:r / (grain) - / 'go:r / (yarn)

There was therefore an even number of stimuli from the two regions, though the /t-d/ opposition was represented twice.

In the Lorraine regions, one minimal pair was selected from each region:

RhF	MF
/ pɛ:r / (horse) - / bɛ:r / (bear)	/ taŋk / (tank) - / daŋk / (thanks)
TR	
/ 'ka:də / (cards) - / 'ga:də / (garden)	

The manipulations carried out were as followed:

i) The amplitude of the plosive release and the following frication was both increased (1.5) and decreased (0.3) for both lenis and fortis consonants. This gave 12 different release phases, 4 per place of articulation[6].

ii) Combined with each of the 4 stop-release strengths were two stop-closure durations (max = 140 ms for the German, 130 ms for the French stimuli; min = 96 ms for both). These were the same for all stimuli.

iii) Each of the stop-closure durations was presented with 100% voicing, 50% voicing, and zero voicing.

These combinations of stop-inherent properties produced (12 x 2 x 3) 72 different stimulus structures in Lorraine, (16 x 2 x 3) 96 in the Saarland/Palatinate due to the duplication of the /t-d/ pair).

iv) These were again presented in both a fortis and a lenis carrier-sentence context (= 144 and 192 stimuli, respectively)

The stimuli were presented, together with the 6 (or 8) originals to 6 listeners from each of the communities.

5.2. Results of perception experiment 2

Figure 5 shows the overall percent fortis judgments (to the nearest percentage point) by the listeners of different regional origin.

The overall pattern of results from the first experiment, which showed greater variability among Lorraine listener-groups than between German listener-groups, is reversed in the second experiment.

[6] Although not critical for the interpretation of results, differentiated amplitude multiplication factors were applied in an attempt to counteract differences in original burst strength. Thus the factors were increased to 1.8 and 0.5 for the (weaker) German RhF- and French MF-production, and decreased to 1.3 and 0.2 for the stronger Lorraine TR-production.

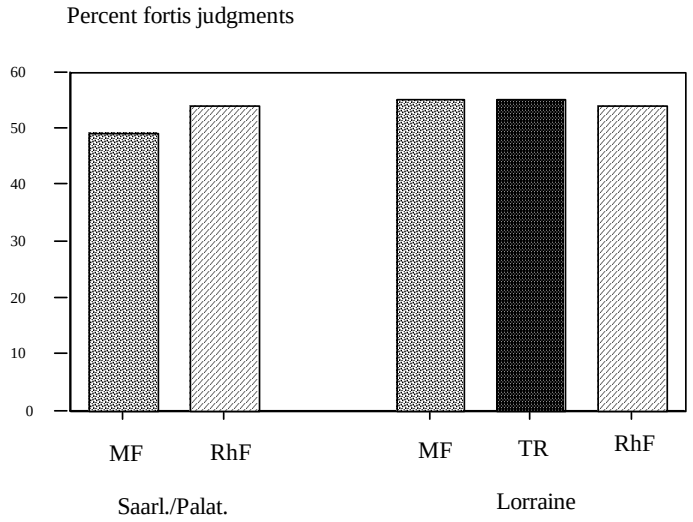

Figure 5. Fortis judgments by listeners of different regional origin.

Figures 6a-6d show the influence of a) stop release, b) stop closure and c) stop-closure voicing, and d) fortis and lenis context on the percentage of fortis judgments.

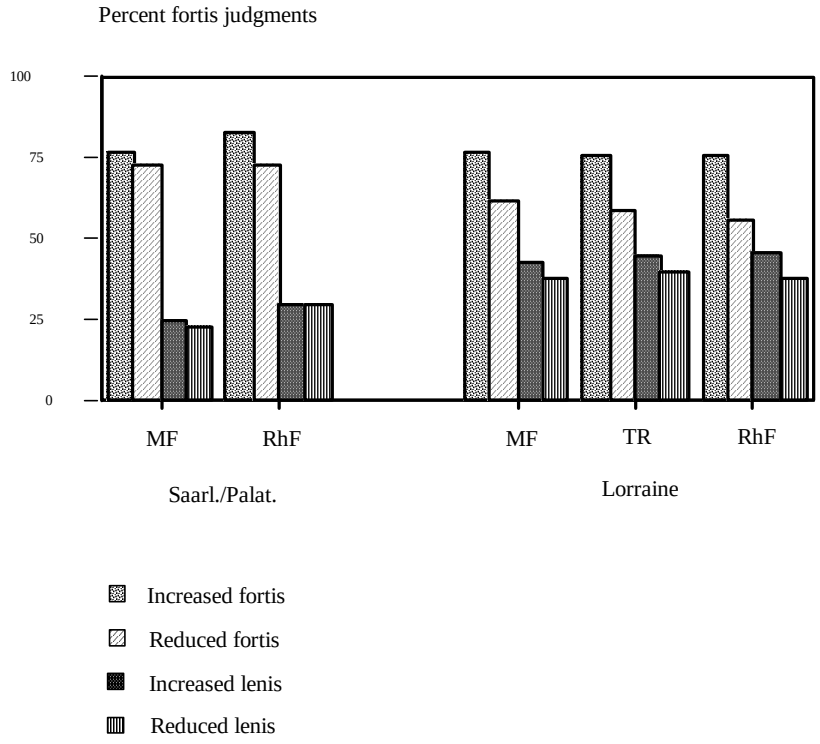

Figure 6a. Influence of stop release.

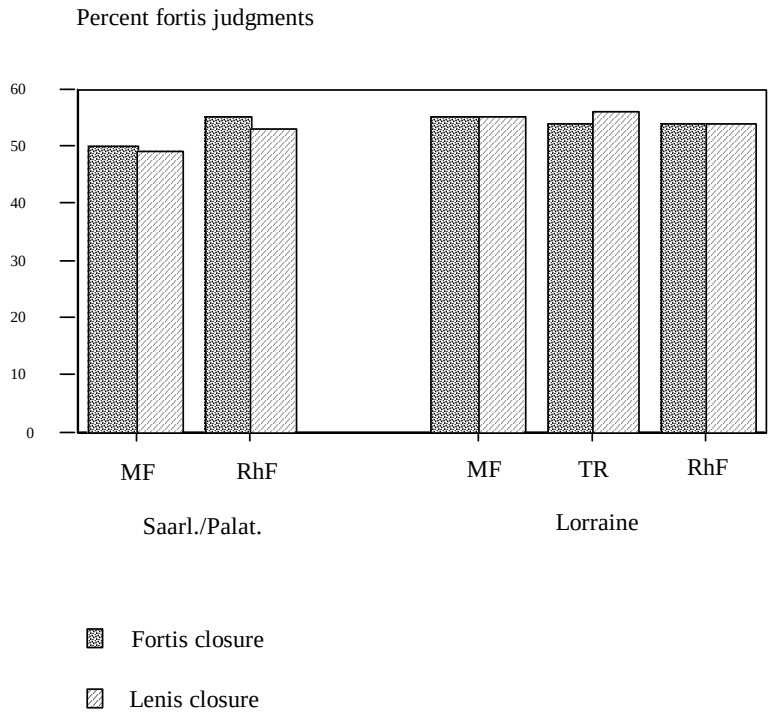

Figure 6b. Influence of stop closure.

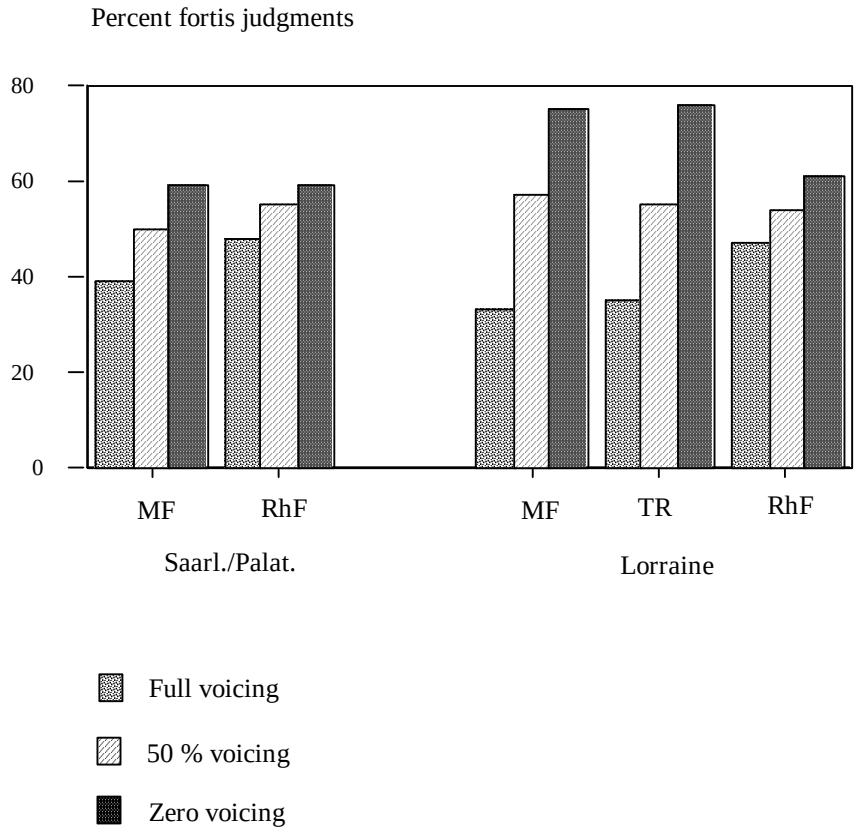

Figure 6c. Influence of stop voicing.

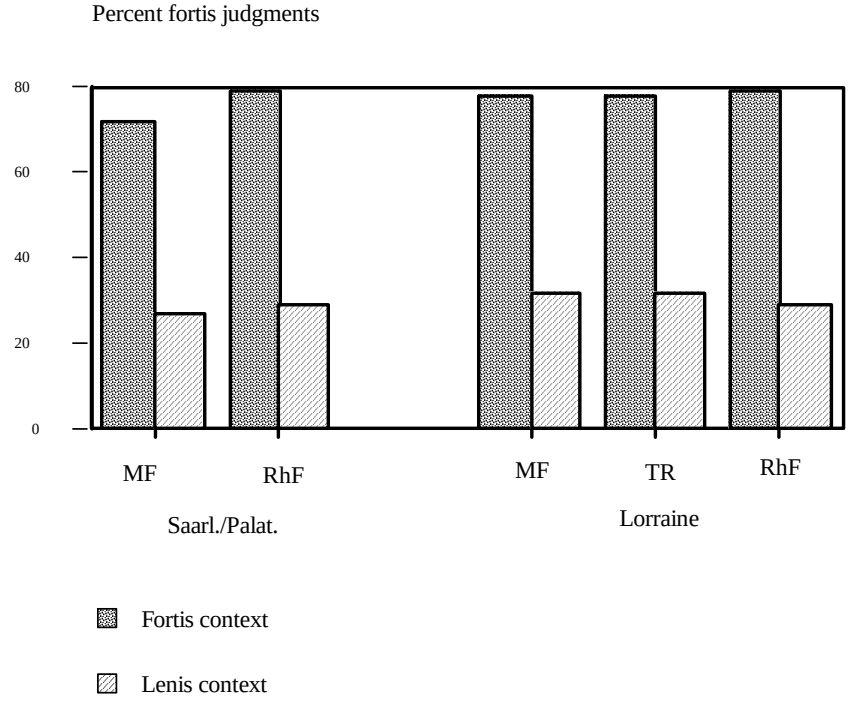

Figure 6d. Influence of fortis and lenis context.

The results can be summarised as follows:

i) The strength of the plosive release has a stronger and more categorical effect on the German listeners. This results in a greater *range* of response than for the Lorraine listeners (> 50% vs. approx. 35%) but with less differentiation between the stronger and weaker versions.

ii) The duration of the stop closure has no effect on the categorisation as fortis or lenis for any of the listener groups, in Germany or in France.

iii) Stop-closure voicing has a stronger effect on Mf than Rhf listeners in both Germany and France, but the overall effect is much stronger for the French than for the German listeners.

iv) There is again a strong but uniform effect of carrier-sentence context across all listener groups.

The ANOVA (Listener group x voicing x context x VOT) shows that all main effects except listener group are significant for the Lorraine listeners (see table VI), and there is a significant interaction between listener group and stop-closure voicing.

The RhF listeners are less sensitive to voicing differences than either the MF or the TR listeners (compare figure 6c).

Table VI. ANOVA results for Lorraine listener: Fortis judgments.

	F	**DF**	**Sign. Level**
Source of Variation			
Listener group	0.21	2	0.811
Voicing	110.25	2	< 0.001
Context	710.19	1	< 0.001
VOT	89.06	3	< 0.001
Sign. Interactions			
List. gr. x Voice	8.62	4	< 0.001
Context x VOT	14.52	3	< 0.001

For the Saarland/Palatinate listeners (see table VII) all main effects are significant, including the listener group. In other words, there is a stronger tendency for the RhF than the MF listeners to categorise the stimuli as fortis. There is no significant interaction between listener group and the other variables, indicating that the difference in listener-group judgments is not dependent on one property of the stimuli rather than another.

Table VII. ANOVA results for Saarland/Palatinate listeners: Fortis judgments.

	F	**DF**	**Sign. Level**
Source of Variation			
Listener group	6.83	1	0.009
Voicing	24.28	2	< 0.001
Context	719.25	1	< 0.001
VOT	252.71	3	< 0.001
Sign. Interactions			
Context x VOT	3.53	3	< 0.015

For both Lorraine and German listeners, the contribution of the fortis and lenis contexts interacts with the contribution of the plosive release phase. This is seen in figure 7, in which the increasing effect of the context with decreasing strength of the stop release becomes apparent.

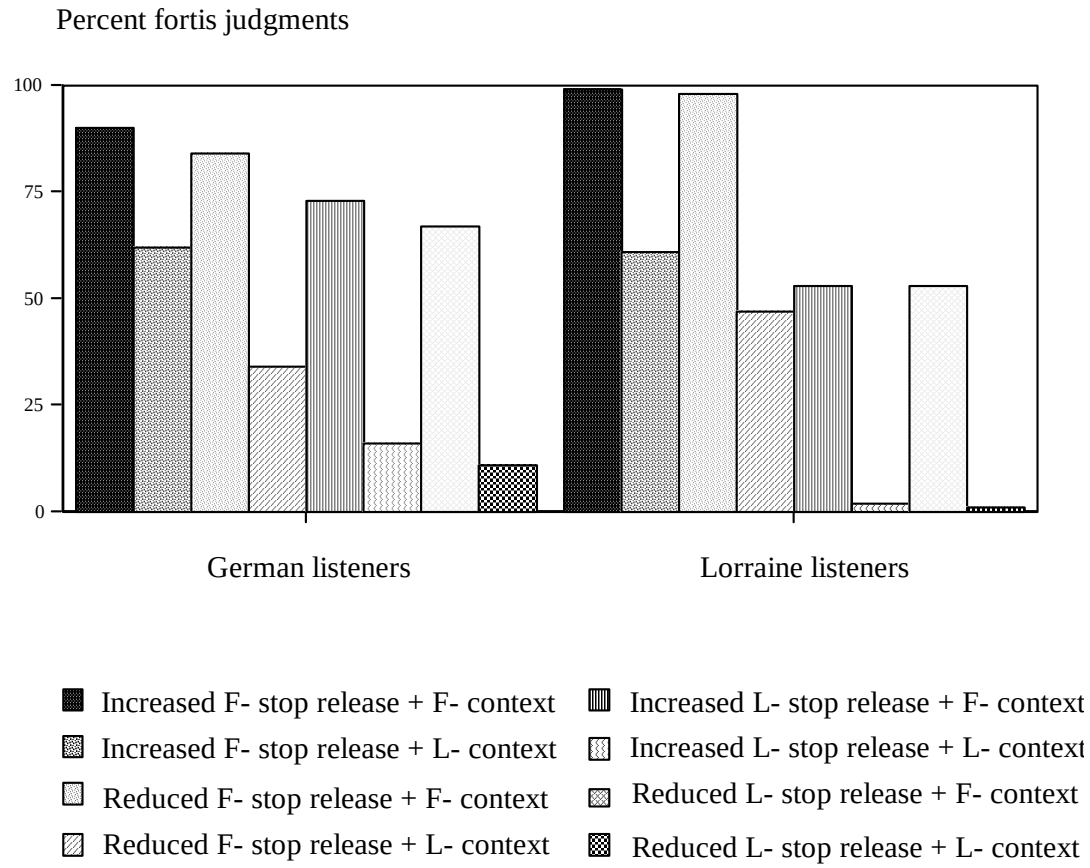

Figure 7. Increasing effect of the context with decreasing strength of the stop release.

6. Summary and Discussion

The production and perception data from German and French Moselle- and Rhenish-Franconian speakers and listeners provide some support for the hypothesis that cross-dialectal communication relies on an approximation process whereby systematic subcategorical production differences are matched by differential perceptual weighting of the acoustic-phonetic properties linked to those differences.

It was shown that there are systematic differences in the way the plosive fortis-lenis oppositions, common to all the regional speaker-listener groups, are realised and processed. Furthermore, the differences in perceptual patterning revealed by the perception results, particularly in the more strictly controlled second perception experiment, are directly relatable to differences in production. They also offer support for the established differences in transcription conventions used for representing the neutralised initial plosive + sonorant clusters in the dialect regions investigated.

On the German side of the border, the RhF listeners made significantly more fortis judgments than the MF listeners, reflecting a greater sensitivity to fortis properties in a region where lenition is more frequent. It was not possible, however, in this case, to link the regional difference in perceptual processing to any of the individual phonetic parameters.The factor listener group interacted significantly with general factor stimulus origin, and with the production factor closure duration, but the latter property was not convincingly different in the production data[7].

In Lorraine there were clear differences between the regional listener groups in the processing of closure voicing, the MF and TR groups showing greater sensitivity than the RhF listeners. This corresponded closely to the differences found in production, where the MF and TR speakers consistently produced lenis plosives with a strongly voiced closure phase whereas the RhF speakers devoiced the lenis closures.

Finally, although a direct comparison of the German with the French dialect speakers is not strictly possible due to the use of different stimulus sets for the perception tests, the parallel structuring of the stimulus series allows the interpretation of the proportion of fortis judgments made under comparable conditions. Thus, the relative insensitivity of the Lorraine RhF listeners to stop-closure voicing, contrasting them to the TR and MF listeners, is comparable to the general insensitivity to stop-closure voicing of both listener groups on the German side. A more general difference between the German and French listeners is their relative sensitivity to differences in stop-release strength. The German listeners reacted almost categorically to strong and weak release bursts, with very little differentiation between the stronger and weaker versions of the fortis and lenis bursts. The French listeners on the other hand, while still using the release bursts to distinguish the fortis and lenis categories, were in addition, sensitive to the intermediate strengths.

[7] The reversal of the usual fortis-lenis relation in closure durations found in the RhF production data (cf. Table I) needs more extensive investigation. If proved to be a genuine

In the introductory discussion, the convergence of experimental phonetic interests in this area of dialectology with those of diachronic studies was recognised. That statement may now be amplified with regard to the importance of experimental methodology for an understanding of the changes that can occur in sound systems.

Any investigation of speech production based on measurements accepts the fact of variability; to support a functional opposition, two statistically separable distributions are required. However, as the data for individual speakers in appendix 1 of this paper documents, the *individual* means and variances for comparable assumed categories also vary. Given the link between production patterns and perceptual cue weighting that was found here, the corollary at the level of speech communication between individuals is the approximation principle hypothesized in the introduction.

In the artificial world of an experiment with manipulated stimuli, the individuals demonstrate different sensitivities to particular properties (cf. also Hazan & Rosen, 1991, Hazan & Shi, 1995), where cues to place and voicing were manipulated). In the real world they collect auditory evidence for a particular word from a complex acoustic input, supplemented by contextually and situationally conditioned expectations. In that situation, with possible masking of acoustic properties by background noise, approximation of sound categories as a process of partial matching is plausible. But how can partial matching become a source of sound change, i.e., a cause of a shift in system categories?

Just as natural selection in biological evolution depends on formal variability within the population of a species interacting with conditions of that species' environment, so the productional variance of sound categories must interact with the perceptual variance tolerated by an interlocuteur's sound categories. Transfer in the listener from the perceived to the produced (i.e., the listener speaks what (s)he has heard) will naturally shift the range of production variance to that established in the listener as a speaker. Thus, the approximation principle of speech communication is, at the same time, the underlying engine of sound change.

The stochastic nature of this perpetual fluctuation in the mean and the range of values from individual to individual provides the necessarily unpredictable basis from which a chance shift of one person's production mean across a listener's perceptual category boundary can occur. Of course, the receiving "environment" must be fortuitously geared to select the reinterpreted form, either in chance cultural contact (e.g. le /vazizdaz/ established in Paris in 1940) or an individual acquiring the language. Once established in an individual, a new form still has to be generalised within a community. Here, the reduction of counter-influences from outside is a prime

factor, since the greater frequency of non-recategorised forms found within a wider community will militate statistically against the chance recategorisation becoming established. However, the many examples of alternative "standard" forms bear witness to the fact that form change does continue even in these days of global exposure to non-local speech (/ 'krɪznɪŋ / & / 'krɪsnɪŋ/; / 'nefju: / & / 'nevju: /; / 'ju:zɪdʒ / & / 'ju:sɪdʒ / etc. cf. Wells, 1995). However, identification with a community is still a psychological force in adopting one form rather than another (e.g. social grouping for /Fr. /wɛ/ vs. /wi/ (oui); nationality with Am. Engl. / tə 'meɪɾəʊ/ vs. Brit. Engl. / tə 'ma:təʊ/ (tomato), and Wells (1995) showed clear though phonologically inconsistent age-group differences among the alternative forms listed above). Also, the opening of dialectal communities to less local social pressures has resulted in a clear levelling of local-community dialect systems, leading to less-differentiated regional systems (Lang, 1985; Herrgen & Schmidt, 1989). Within the communities in Lorraine covered by this study, changes across the generations were more clearly moving towards the standard German forms in the Southeast (RhF speakers), where knowledge of German is of greater commercial use, than in the Northwest (MF), where cultural initiatives appear to be the driving force behind the maintainance of the Germanophone dialects (Pützer & Barry, 1998; Pützer & Barry, 1999).

To conclude, we wish to offer for consideration the theory that natural variation in the realisation of sound categories within any speaker-hearer means that there is a fundamental mismatch between the phonetic bases of any two interlocuteurs' sound systems. This mismatch will naturally vary with the dialectal proximity of their idiolects. But the need to match the speaker's acoustic production with the hearer's perceptual "prototypes" requires a decoding strategy which we have called "idiolect approximation". The ubiquity of idiolect approximation in speech communication also supplies the stochastic base for sound change since every production of a perceived category (perhaps with the exception of skilled mimicry) represents an idiolectal shift along the axis of variation. Chance selection of a categorical shift can result in a "form change" at individual level, which still has to establish itself at community level.

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Appendix 1

Average durations in ms for Stop Closure (Cldur), Closure voicing (Clv) and Voice onset time (VOT) for individual speakers

German MF speakers

	Fortis			**Lenis**		
	p	t	k	b	d	g
Speaker: AP						
Cldur	144	149	139	134	130	133
Clv	8	6	8	14	7	13
VOT	28	35	66	9	11	26
Speaker:GS						
Cldur	141	148	138	141	115	126
Clv	15	8	7	50	15	52
VOT	48	68	71	9	10	17

German RhF speakers

	Fortis			**Lenis**		
	p	t	k	b	d	g
Speaker: MP						
Cldur	108	110	89	128	121	106
Clv	8	6	8	10	15	20
VOT	42	54	69	14	11	26
Speaker: EB						
Cldur	122	107	109	142	110	132
Clv	12	7	8	14	10	10
VOT	35	50	62	8	12	13

French MF speakers

	Fortis			**Lenis**		
	p	t	k	b	d	g
Speaker: PD						
Cldur	88	78	67	80	64	55
Clv	28	13	7	73	53	49
VOT	40	32	48	11	14	18
Speaker: JB						
Cldur	94	83	70	89	75	61
Clv	16	8	9	89	75	61
VOT	62	39	65	11	14	15

French TR speakers

	Fortis			**Lenis**		
	p	t	k	b	d	g
Speaker: AT						
Cldur	178	145	125	138	136	96
Clv	21	16	19	75	82	57
VOT	61	61	71	8	14	22
Speaker: GK						
Cldur	168	197	127	153	154	119
Clv	31	17	15	90	28	45
VOT	37	34	47	8	11	12

French RhF speakers

	Fortis			**Lenis**		
	p	t	k	b	d	g
Speaker: AK						
Cldur	169	285	247	203	293	264
Clv	40	33	32	39	45	39
VOT	23	31	67	14	16	25
Speaker: MCW						
Cldur	161	190	123	176	175	135
Clv	30	32	12	36	45	26
VOT	25	46	65	12	14	17

Appendix 2

Minimal pairs

German MF speakers

/ 'paus / (Pause, Engl. pause) - / 'baus / (Beule; Engl. boil/dent)
/ 'taŋk / (Tank; Engl. tank) - / 'daŋk / (Dank; Engl. thanks)
/ 'ko:r / (Korn; Engl. corn) -/ 'go:r / (Garn; Engl. thread)

German RhF speakers

/ pɛ:r / (Pferd; Engl. horse) - / bɛ:r / (Bär; Engl. bear)
/ taŋg / (Tank; Engl. tank) - / daŋg / (Dank; Engl. thanks)
/ 'kʊmər / (Kummer; Engl. worry) - / 'gʊmər / (Gurke; Engl.gherkin/cucumber)

French MF speakers

/ pɛ:r / (Pferde; Engl. horse) - / bɛ:r / (Bär; Engl. bear)
/ pu:r / (Paar; Engl. pair) - / bu:r / (Brunnen; Engl. well)
/ tɔrf / (Torf; Engl. peat) - / dɔrf / (Dorf; Engl. village)
/ taŋk / (Tank; Engl. tank) - / daŋk / (Dank; Engl. thanks)
/ kas / (Kasse; Engl. cashbox/till) - / gas / (Gasse; Engl. lane)
/ kɔat / (Karte; Engl. cart) - / gɔat / (Garten; Engl. garden)

French TR speakers

/ pɛ:r / (Pferde) - / bɛ:r / (Bär)
/ te:r / (Teer) - / de:r / (Dornen)
/ taŋk / (Tank) - / daŋk / (Dank)
/ 'ka:də/ (Karten) - / 'ga:də/ (Garten)

French RhF speakers

/ pɛ:r / (Pferde) - / bɛ:r / (Bär)
/ 'pɛ:rə/ (Pferde) - / 'bɛ:rə / (Bären)
/ tɔŋ / (Tank) - / dɔŋ / (Dank)
/ tɔŋg / (Tank) - / dɔŋg / (Dank)
/ 'kʊmər / (Kummer) - / 'gʊmər / (Gurke)
/ kiʃd / (Kiste) - / giʃd / (Gicht)