Final Devoicing and Neutralisation·

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Abstract

This paper takes a new look at the concept of neutralisation in the context of final devoicing in German. It briefly traces the history of neutralisation in phonological theory and discusses some of the experimental work which has examined final devoicing as a putative process of neutralisation over the past decade. It points out that some of the findings of this work pose problems for the phonological theories which first inspired the experimental research activity in this area. These problems are then confronted with a recent analysis of final devoicing couched in the framework of Government Phonology. It is shown that the apparent problems for phonological theory raised by the experimental studies can be resolved by Government Phonology.

1 Introduction

The phonological process of final devoicing (also known as terminal devoicing or final obstruent devoicing; henceforth FD) has been cited as one of the prime examples of phonological neutralisation for over 50 years. This view of it, however, has become quite controversial over the past decade. A lively debate about whether it is mistaken or not fills much of the experimental literature of that period (see, for example, Port *et al.* 1981, O'Dell & Port 1983, Dinnsen & Charles-Luce 1984, Fourakis & Iverson 1984, Charles-Luce 1985, Dinnsen 1985, Port & O'Dell 1985, Port & Crawford 1989).

In this paper, I would like to try and unravel some of the issues mixed up in this debate and see what can be learnt from it.

I will begin with a brief overview of the history of the theoretical construct of neutralisation, which will be followed by a discussion of the most important findings of the experimental work on FD in German in the context of phonological neutralisation. I will point out some of the implications of this research for the phonological theory which inspired this work in the first place, but which doesn't appear to have benefited from it at all.

·I would like to thank John Harris for his comments on an earlier draft of this paper. Any errors are, of course, my responsibility. I am also grateful to Stamatoula Pagoni for helpful discussions.

I will then introduce my own phonological analysis of FD, which is couched in the framework of Government Phonology (see Kaye *et al.* 1985, Kaye *et al.* 1990, Charette 1988, 1990, Harris 1990 and Kaye 1990 for details). From the vantage point of this element-based (rather than binary feature-based) analysis, I will then be in a position to identify some problems raised by the experimental studies as being artifacts of the phonological framework the studies took as their point of departure.

I will show that some of the basic tenets of Government Phonology (henceforth GP) make it possible for the remaining problems arising from the experimental work to be resolved.

2 The story of neutralisation and the traditional place of FD

2.1 Neutralisation from Trubetzkoy to Kiparsky

The notion of neutralisation was first introduced by Trubetzkoy in two 1933 papers (see Davidsen-Nielsen 1978: 27). In his seminal work *Grundzüge der Phonologie*, published six years later (Trubetzkoy 1939 [1969]), he uses the term neutralisation to cover a much wider range of possibilities than most writers on the topic after him. This high degree of differentiation is made possible through his use of the concept of the archiphoneme (first introduced by Roman Jakobson in 1929), which he defines as 'the sum of distinctive properties that two phonemes have in common' (Trubetzkoy 1939 [1969]: 79). In his view, there are four different cases of neutralisation to be found in natural languages.

In the first case, neither of the opposition members involved in the neutralisation is actually identical with the realisation of the archiphoneme in the position of neutralisation. In other words, given an opposition between segments α and β, what appears in the neutralisation environment will be a third segment γ, where γ has some properties of both α and β, without being identical with either of them. A reasonable example of this type of neutralisation would be the English flapping rule which merges the contrast between /t/ and /d/ into a new segment (often transcribed as [D]) which differs from both the two input segments (see Dinnsen 1985: 266).

In the second case, one of the opposition members is identical with the phonetic realisation of the archiphoneme in the position of neutralisation. The choice of which member occurs here is conditioned 'externally', in Trubetzkoy's terms, i.e. is dependent on the phonological properties of an adjacent phoneme. Voicing assimilation of obstruents (e.g. in Polish or Russian) would be an example of this case.

The third case is like the second, except for the fact that the choice of which member of the opposition represents the archiphoneme is conditioned

'internally', that is, in a privative opposition, the unmarked member of the pair will be chosen in the neutralisation environment by virtue of its being unmarked. FD could serve as an example here, provided, of course, that the realisation of final /d/ is actually identical with the realisation of /t/ in the same environment.

The fourth case, which Trubetzkoy admits is rather rare and very often consists of a combination of the second and third cases, has *both* members of the neutralised opposition representing the archiphoneme in the neutralisation environment, one in one type of environment and the other in another. He gives the opposition of German [s] - [ʃ] as an example of a genuine (i.e. non-combinatory) instance of Case IV. He argues that this opposition is neutralised before consonants, with [ʃ] occurring root-initially and [s] root-medially and finally (p. 82).

A much more restrictive definition of neutralisation is advanced in Kiparsky 1976 (p. 169), where the concept of neutralisation plays a crucial role in the phrasing of the Alternation Condition (see Kiparsky 1976: 167f.). It takes the following form.

> 'Suppose we have a phonological process P:
>
> (P) A → B / XC __ DY
>
> where C and D represent a (phonological and/or morphological) context, and X and Y are arbitrary strings. Then,
>
> (a) ...
> (b) P is NEUTRALIZING if there are strings of the form CBD in the immediate input of P; otherwise P is NON-NEUTRALIZING.' (emphasis his)

What this definition says is that for a process to be neutralising the output B which it generates must already be present in the system. If B (or, more precisely, CBD) is not available as a potential input to P, then the process is non-neutralising. In other words, Trubetzkoy's Case I is excluded. So, English flapping, for example, would no longer qualify as a neutralisation process. This definition of neutralisation appears to have been accepted fairly generally in generative phonology, and some analyses crucially depend on it (e.g. Houlihan & Iverson 1979).

Kiparsky 1982a, however, marks the beginning of a substantial decline in the importance of neutralisation as a theoretical construct. The Alternation Condition, to which neutralisation was so important, is exposed as being seriously flawed, for, among other things, 'it is ... not a formal condition of the desired sort because the property of being a "neutralization rule" is not determinable from inspection of the grammar' (Kiparsky 1982a: 152). Except for informal use (which I will briefly touch upon at the end of this paper), the

term 'neutralisation' seems to have all but disappeared from phonological discussion.

Its spirit, though, lives on in the structure preservation constraint of Lexical Phonology (see, for example, Pulleyblank 1986: 7). A structure-preserving rule is very similar indeed to a neutralisation rule by Kiparsky's 1976 definition. Structure preservation may be somewhat less restrictive in that it does not require elements C and D in Kiparsky's 1976 definition of neutralisation. For B to be underlyingly present is sufficient. Also, neutralisation can be interpreted as a special case of structure preservation in that it relates to segmental structure only. Structure preservation (at least in its most recent formulation, see Borowsky 1989[1]) also covers prosodic structure, such as constraints on the number of positions within a coda for example.

2.2 The orthodox generative view of FD and neutralisation

In this section, I will summarise briefly the position adopted in, to my knowledge, practically all published work since Vennemann 1968.

FD has essentially been dealt with in an SPE-type rule which specifies obstruents as being voiceless in some environment E. This is usually expressed in the rewrite rule [– son] → [– voice] / E. The rule predicts that what appears as [b] in one environment will emerge as [p] in an FD environment and so on. This is illustrated for German in the data set in (1), which covers all obstruents exhibiting voicing alternations[2].

[1]She observes that the definitions of structure preservation advanced by Kiparsky and herself in 1985 and 1986 respectively suggested (without being entirely clear on this) that only segmental constraints were structure preserving. In her paper, she makes a strong case for explicitly including prosodic structure in the domain of structure preservation.

[2]For typographical reasons, [r] does no have its IPA value. Prevocalically it represents a uvular approximant, while postvocalically *r* is frequently vocalised.

(1)	*Spelling*	*No FD*	*FD*	*Gloss*
	gelbe	[gɛlbə]		'yellow' (fem. sg. nom.)
	gelb		[gɛlp]	'yellow'
	gelblich		[gɛlplɪç]	'yellowy'
	Kinder	[kɪndər]		'children'
	Kind		[kɪnt]	'child'
	Kindchen		[kɪntçən]	'little child'
	bergig	[bɛrgɪç]		'mountainous'
	Berg		[bɛrk]	'mountain'
	bergarm		[bɛrk?arm]	'lacking in mountains'
	Hause	[haʊzə]		'house' (dat. sg.)
	Haus		[haʊs]	'house'
	Hausecke		[haʊs?ɛkə]	'corner of the house'
	brave	[bra:və]		'well-behaved' (nom. pl.)
	brav		[bra:f]	'well-behaved'
	Bravheit		[bra:fhaɪt]	'good behaviour'

Given this SPE-type analysis, FD obviously qualifies as a neutralisation process in Trubetzkoy's terms, an instance of Case III. That it also meets the requirements of Kiparsky's more restrictive 1976 definition is made clear by the data set in (2). The left-hand column shows words which would constitute 'strings of the form CBD' as input to P and the right-hand column contains words with apparently identical CBD strings (as far as the pronunciation, but not necessarily the morphological structure is concerned) which, in fact, were changed from CAD to CBD by the application of FD. The relevant environment is italicised in the orthography.

(2)

A*lptr*aum	ha*lbtr*ocken
[alptraum]	[halptrɔkən]
'nightmare'	'medium dry'
a*ltb*acken	W*aldb*eere
[altbakən]	[valtbe:rə]
'old-fashioned'	'fruit of the forest'
W*erkw*ohnung	B*ergw*acht
[vɛrkvo:nuŋ]	[bɛrkvaxt]
'company-owned flat'	'mountain rescue service'
Sch*afh*erde	B*ravh*eit
[ʃa:fhe:rdə]	[bra:fhaɪt]
'flock of sheep'	'good behaviour'

The SPE-type analysis of FD, then, leaves no doubt about its neutralising status, regardless of whether one chooses to subscribe to a broad (Trubetzkoy) or a narrow (Kiparsky) interpretation of that concept.

The period of increased importance for neutralisation as a theoretical construct which began in the early 70's and came to a close with Kiparsky 1982a partly overlapped with a time of change in phonetics. There was a marked shift in the attitude of phoneticians towards the relationship of their science with the more theoretical aspects of linguistics, and phonology in particular. Well into the 1970s, the general consensus had been that phonetics was charged with establishing how exactly the linguistically determined categories were borne out in the 'real world' of speech sounds. This view met with increasing dissatisfaction from practising phoneticians, resulting in a conscious effort to establish 'experimental phonetics as a serious contribution to theory and explanation in phonology rather than as a mere field of additional concrete descriptive statements' (Kohler 1984: 151). The title of Ohala's 1974 paper (phonetic explanation in phonology) constitutes a kind of manifesto of this new approach to phonetics. Neutralisation was one of the first issues to be tackled, with final devoicing in German, *the* textbook example of it, attracting most attention (see § 1 for references).

3 The neutralisation debate in the experimental literature

3.1 The studies and their findings

Most of the work was carried out in the United States. As far as one can tell, all researchers based their work on Kiparsky's 1976 definition of neutralisation, although only a small minority state this explicitly. What is clear, though, from the ways the studies are conducted is that neutralisation is interpreted as a devoiced obstruent becoming indistinguishable from its underlyingly voiceless congener.

It turned out that it was extremely difficult to establish this reliably. The most important problems were connected with the set-up of the relevant experiments and the choice of test words (and, occasionally the voicing status assigned to the underlying segments; e.g. Mascaró 1987). One of the objections taken most seriously was that experiments which involved reading lists encouraged so-called spelling pronunciations. The problem was that, in a language such as German, the spelling of the alternating segment remained unchanged, regardless of whether it was pronounced as voiced or voiceless (see (1) for examples). It was argued (in Fourakis & Iverson 1984, for example) that this 'voiced' spelling suggested to the experimental subject a voiced sound or at least some residue of voicing which then led to a distortion of the results. The researchers explored two different ways of overcoming this problem.

Firstly, test words were elicited without reading lists by orally cueing subjects for an infinitive form of a verb which had to be conjugated. The preterite form contained the desired FD obstruent (see Fourakis & Iverson 1984). Secondly, studies were carried out on languages where the spelling of FD obstruents generally changes with their voicing value (see Dinnsen & Charles-Luce 1984, Mascaró 1987 and Charles-Luce & Dinnsen 1987).

The findings were less clear-cut than the researchers had hoped. Some studies had negative results, i.e. no statistically significant differences between underlyingly voiceless obstruents and their devoiced congeners were identified (e.g. Fourakis & Iverson 1984 for German and Jassem & Richter 1989 for Polish). Others, however, reported positive results, i.e. statistically significant differences between these groups of voiceless obstruents had been observed (e.g. Port *et al.* 1981, O'Dell & Port 1983, Port & O'Dell 1985 and Port & Crawford 1989 for German; Slowiaczek & Dinnsen 1985 for Polish and Dinnsen & Charles-Luce 1984 and Charles-Luce & Dinnsen 1987 for Catalan). It is hard to say what exactly the reasons for the differing results were, but it appears that the details of the experimental set-up and the statistical methods of analysis may have been decisive.

There can be no doubt that the differences in the production of devoiced obstruents and underlyingly voiceless obstruents are very small indeed, but, in my view, those researchers who observed these differences and showed that they are statistically significant have a better case than those who argued that the differences are non-existent or not significant. Firstly, the former used a much wider range of different experiments and statistical methods than the latter, and still succeeded in consistently coming up with similar findings. Secondly, as Dinnsen (1985) points out, the failure to find statistically significant differences does not necessarily mean that they are not there. Perhaps the researchers were looking in the wrong place.

Before discussing the findings and the issues they raised further, let me first describe the general pattern of the experimental design to which most of the studies conformed, to show how these findings were actually arrived at. This section covers studies on German only.

Words containing alternating obstruents in FD environments (i.e. realised as voiceless) were elicited from native speakers together with similar words with underlyingly voiceless obstruents, so that sets of minimal pairs (e.g. *Rad* 'wheel' and *Rat* 'advice') or near-minimal pairs were recorded (the focus of the experiment was usually disguised by mixing these words with others not relevant to the study). These recordings were then used for measurements of various temporal aspects of these words. Most commonly, the researchers measured the duration of the vocalic nucleus preceding the obstruent under investigation, the duration of the period for which glottal pulsing continued from the preceding nucleus into the closure or friction phase of the obstruent itself and the duration of the closure or friction phase of that obstruent.

As shown in (3), it was found that underlyingly voiced obstruents differed from their underlyingly voiceless congeners in that the preceding vowel was longer, the duration of voicing into closure or friction was greater and the duration of the closure or friction phase was shorter.

(3)

Phonetic variables	*Most common findings*	
	Underlyingly voiced	*voiceless*
Duration of preceding vocalic nucleus	longer	shorter
Duration of voicing into closure/friction (from the left)	longer	shorter
Duration of closure/friction	shorter	longer

To see whether the contrast which was maintained in the production of obstruents was also perceptually salient, listening tests were carried out. For this purpose, recordings of a large number of tokens (usually the words used in the production experiments) were played to native speakers of German (not those used in the production experiments, of course), whose task it was to pick out the form they believed they had just heard from two choices presented to them on an answer sheet. The overall percentages for correct responses are shown in (4). In some cases, these are the means of results from several experiments conducted as part of a single study.

(4)

Study	*Percentage of correctly identified tokens*
Port *et al.* 1981	70%
O'Dell & Port 1983	63%
Port & O'Dell 1985	59%
Port & Crawford 1989	69%

The relatively wide range of these results is due to differences in the experimental set-up (in one case, for example, speakers were told to dictate the words to someone when the recording was made, so their pronunciation was exaggerated to reflect the spelling - interestingly, however, not to such an extent that the listeners were able to identify much more than about 70% of the words correctly). Whatever the most representative figure may be, it is clear that the level of correct responses cannot be due to mere guessing. The performance of the subjects may have been poor, but it was still consistently better than chance. The researchers concluded that the underlying voicing distinction is maintained to the extent of being perceptually salient. However,

it does not seem to be salient enough to be of much use in normal communication.

Apart from the original issue of neutralisation, to which I shall return shortly, a number of other questions were raised by this experimental research.

Most of them fall into one of two categories, the question of the relationship between production and perception, and the issue of how exactly the output of the phonology is implemented phonetically. I shall discuss them in turn, starting with the issue of production vs. perception.

3.2 The relationship between production and perception

It is clear from (3) and (4) that there is a certain mismatch between production and perception concerning the distinction between underlyingly voiceless vs. devoiced obstruents. The production facts suggest that the two are different, as do the perception facts - but only to a point. Even if 60-70% of all word-final voiceless obstruents can be correctly identified as underlyingly voiceless or devoiced by native speakers/hearers, that leaves too great an error margin for anyone to wish to say that this is used to carry information crucial for successful communication.

On the contrary, it appears that it is the semantic and syntactic context available in normal communication which enables the hearer to pick the correct member of a virtually homophonous pair such as *Rat* - *Rad*. Fay & Cutler (1977) suggest that phonologically similar words are stored close together, but at the same time they recognise that words have to be incorporated into a network based on semantic and syntactic categories for the purposes of production (see Aitchison 1987 for details of this network). Assuming that the lexical representations of both *Rad* and *Rat* are initially accessed by the hearer, say, in a conversation about bicycle maintenance, she will be able to finally choose *Rad* as the right member of the pair on the basis of the semantic information supplied by the speaker. Provided, then, that the two members of these practically homophonous pairs are not actually in the same semantic field and in the same word class, the context will generally prevent the hearer from accessing the wrong one. My own informal survey of such pairs in German suggests that this is the case.

For the purposes of communication, the contrast between the two groups of voiceless obstruents is then very unlikely to be significant. As far as perception is concerned, neutralisation (in Kiparsky's sense) is perhaps complete after all. One conclusion one could draw from this is that the statistically significant differences in production are linguistically not significant. How can this mismatch between production (where consistent differences have been observed) and perception (where the difference is only marginally salient) be captured in a grammar which is neutral with regard to

speaker vs. hearer? This neutrality is, after all, one of the basic assumptions about the grammar in current mainstream thinking in generative phonology. The question of how to deal with this mismatch is discussed by Dinnsen (1985) as part of his review of the concept of neutralisation.

He concludes that it is impossible to reconcile such differences between production and perception, and suggests that production and perception should be seen as being at least partially independent of one another (see also Klatt 1981 for detailed arguments in favour of the dual-lexicon hypothesis).

Obviously, the dual-lexicon hypothesis is far too big an issue for a satisfactory discussion in the present paper. What matters for our purposes is that, from the phonologist's point of view, it would be preferable to be able to work with a single lexicon. This would avoid additional problems, such as a substantial complication of the grammar, concerns about storage space and questions regarding the interaction between the two lexicons. Ideally, one would hope that a single lexicon could accommodate both production *and* perception (see Fay & Cutler 1977 for evidence from production errors which supports the view that there is just one lexicon).

Whatever one's view of other arguments advanced in favour of the dual-lexicon hypothesis may be (e.g. in Klatt 1981), as far as FD is concerned, I will argue that the mismatch between production and perception can be resolved without resorting to the dual-lexicon. I will discuss this below, in the context of my Government Phonology analysis of FD.

3.3 The implementation of FD

The second additional issue raised by this experimental work concerns the phonetic implementation of FD. The researchers wondered how the systematic production difference between underlyingly voiced obstruents and their underlyingly voiceless congeners in FD environments could be reconciled with the prevailing assumption that the two were identical phonologically.

Phonetic implementation rules were invoked to deal with this problem. Specifically, it was suggested (in Port & O'Dell 1985) that phonetic implementation rules should not just be understood as implementing segments and segmental features, but as implementing properties of whole syllables as well. In the context of FD, the idea was that an underlyingly voiced syllable-final obstruent would not undergo a devoicing rule in the phonology, but would become the input to the relevant implementation rule with its [+ voice] specification intact. The syllable implementation rule would then initiate 'a gesture that resembles the segmental implementation of [– voice]' (p. 468). This would guarantee that both [– voice] and syllable-final [+ voice] segments were pronounced in a very similar way, but not identically.

Implementation rules, like the dual-lexicon hypothesis, are a complex and widely-debated issue (at least in the phonetic literature), an issue that cannot be done justice to in a paper such as the present. I will, therefore, consider only how FD would fare in a grammar incorporating both phonological rules and phonetic implementation rules.

An important question which has been discussed by proponents of such implementation rules is how exactly they interact with phonological rules. One of the clearest statements of this relationship I am aware of comes from the phonological (Lexical Phonology) rather than the phonetic literature. Pulleyblank (1986: 7f.) suggests that the phonetic rules (I believe that these are essentially the same as Port & O'Dell's (1985) implementation rules) should apply after all phonological rules, that is, the input of the phonetic component is the output of the post-lexical phonology. According to Port & O'Dell's (1985) proposal, FD would not be dealt with by the phonology, so that FD obstruents would proceed without change to the phonetic component, where the syllable implementation rule would initiate the correct gesture.

Intriguingly, however, this is not the approach adopted by those phonologists who have developed an analysis of FD in the theoretical framework in which Pulleyblank operates, that of Lexical Phonology. Both Rubach (1990) and Hall (1989a, b) account for FD in terms of a phonological rule (a post-cyclic rule in Rubach's case and a post-lexical rule in Hall's[3]). In other words, the currently available Lexical Phonology approaches to FD are beset with the very problems which led to Port & O'Dell's proposals about implementation rules in the first place. Both underlyingly voiced and underlyingly voiceless obstruents enter the phonetic component with a [– voice] specification, which, counter-factually, predicts identical realisations for both in FD environments.

For the present discussion of implementation rules, however, choices made for existing analyses (such as Rubach's and Hall's) are not crucial. What really matters is whether it is possible *in principle* to deal with FD in the phonetic (as opposed to the phonological) component. Consider the following words taken from Rubach 1990 (p. 84).

[3]See Booij & Rubach 1987 for a detailed discussion of the differences between post-cyclic and post-lexical rules.

(5)	*Voiced obstruent*	*Voiceless obstruent*
	Handl+ung 'act' (handel+n 'to act')	hand+lich 'handy'
	Ordn+ung 'order' (ordn+en 'regulate')	Bild+nis 'portrait'
	ebn+en 'flatten' (eben 'flat')	Ergeb+nis 'result'
	Begegn+ung 'meeting' (begegn+en 'meet')	Wag+nis 'boldness'
	eign+en 'own' (eign+en 'to own')	Zeug+nis 'testimony'
	nebl+ig 'foggy' (Nebel 'fog')	glaub+lich 'believable'

As far as I know, it is uncontroversial among phonologists who have dealt with data of this kind in a syllabic framework that the FD obstruents in all these words are syllabified into the coda[4]. This syllabification is obligatory (or at least strongly preferred, according to Vennemann's Law of Initials (see Vennemann 1972, 1988)), except for *Begegnung*, *eignen* and *neblig*, where an alternative syllabification into *Bege.gnung*, *ei.gnen* and *ne.blig* is possible. However great the differences between various phonological analyses may be, the general consensus is that these words (and others like them, of course) leave the phonological component with a syllable-final obstruent.

The implementation rule proposed by Port & O'Dell takes such syllable-final obstruents as its input and hence initiates the appropriate gesture for devoiced obstruents in these words. This, however, is wrong for *Handlung*, *Ordnung*, *ebnen* and so forth, where FD does not actually apply. In other words, implementation rules which take their input from the output of the phonology generate incorrect forms for a number of German words.

It seems, then, that implementation rules are unable to solve the problems with FD. Perhaps something more fundamental is amiss, which makes it impossible for an SPE-derivative framework using binary features to handle the phenomenon of FD.

[4]Note, however, that this view differs fundamentally from the Government Phonology approach to the syllable in general (see references in § 1) and to words such as those in (5) in particular (see Brockhaus 1990a).

3.4 Experimental studies and phonological neutralisation

Given that most of the experimental studies were based on Kiparsky's 1976 definition of neutralisation, it is clear that those which reported differences between underlyingly voiced and voiceless obstruents in FD environments could only conclude one thing: FD was not a neutralisation process. By Trubetzkoy's classification, FD would still have qualified as a neutralisation process (an instance of Case I), but Kiparsky's more recent approach, where a particular interpretation of neutralisation was crucial to the theory, denied its neutralising status.

In fact, Dinnsen (1985) argued that not only was FD not a neutralisation process, but that *all* putative neutralisation processes turned out to be non-neutralising under closer scrutiny. The consequences of this for the sort of phonological theory which depended on neutralisation as a theoretical construct could have been serious. However, Dinnsen's claims seem to have had no perceptible effect on phonological debate. Part of the reason for this may have been the fact that, by the time Dinnsen made his claims, neutralisation by that name was already playing a substantially reduced role in mainstream phonological thinking (see Kaisse & Shaw 1985: 24*f.*). Also, the notion of structure preservation (which had been introduced in Kiparsky 1982b) was being used to capture what had previously been handled by neutralisation (segmental structure), and possibly even more than that (prosodic structure; see fn. 1).

As far as Dinnsen's observations were concerned, though, the new Lexical Phonology broom of structure preservation swept only slightly better than the old one of neutralisation. The implication would have been that structure preservation was limited to prosodic structure only (if that). This, of course, would have meant substantial erosion (or even complete wiping out) of this theoretical construct. In fact, a considerable amount of evidence has come to light in recent years which suggests that structure preservation is much more limited than previously assumed (see, for example, Borowsky 1989, Hall 1989b and Harris 1987, 1989) - something which could be interpreted as a vindication of Dinnsen (1985). So, work in phonology could perhaps have benefitted from taking on board some of the concerns arising from phonetic research.

3.5 Summary

To summarise, experimental studies which set out to establish whether FD was a neutralisation process in the narrow sense (Kiparsky 1976) came to the conclusion that it was not, a fact which, when taken together with similar findings for other alleged neutralisation processes, could have had important repercussions for phonological theory, but which was generally ignored in phonological debate.

These studies also found evidence that there was a mismatch between production and perception, with speakers being largely unable to reliably perceive distinctions which other members of their speech community (and presumably they themselves) produced. This problem was seen as a strong argument in favour of the dual-lexicon hypothesis, a highly controversial issue which, on the whole, has been absent from phonological debate.

Finally, in the light of the fact that the predictions made by the phonology were not borne out by the production facts, some researchers suggested that special implementation rules should handle FD. This meant that FD was thus interpreted as a phonetic, as opposed to a phonological, process. However, as I have shown, it does not appear to be possible to accommodate FD in such a system.

I will now take a look at a recent analysis of FD in a different framework, that of Government Phonology, and compare its performance with that of the linear analysis. It will become apparent that some of the problems just summarised are simply artifacts of an unsuitable theoretical framework and that the remainder can be resolved in the framework of GP.

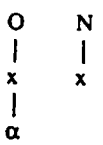
4 The Government Phonology analysis

4.1 The proposals

My GP analysis (first presented in Brockhaus 1990a, with some additional arguments in Brockhaus 1990b) makes the claim that FD is a phonological weakening process which involves the loss of the laryngeal element L^-. GP recognises two laryngeal elements, L^- and H^-, which 'control (non-spontaneous) voicing properties in consonants and represent tone on vowels' (Kaye *et al.* 1990: 216). When present in the representations of consonants, L^- is associated with full voicing and H^- with voicelessness. Obstruents lacking a laryngeal element altogether are to be interpreted as neutral, that is, as articulated without any active laryngeal gesture (see Harris 1990: 264; also Halle & Stevens 1971, which inspired these definitions).

The claim I want to make here is that those German obstruents which exhibit voicing alternations contain L^- in their lexical representations. In an FD environment, this L^- is delinked. An FD environment takes the form shown in (6).

(6)



The variable α represents an FD obstruent. This obstruent is followed by a licensed empty nuclear position, most commonly a parametrically licensed domain-final empty nuclear position. To elucidate what is meant by licensing in this context, let me refer to the Licensing Principle, as quoted from Kaye 1990 (p. 306) below.

(7) *Licensing Principle*
All phonological positions save one must be licensed within a domain. The unlicensed position is the head of this domain.

Government is a form of licensing, and each onset enters into a governing relation with the nucleus which immediately follows it. The nucleus is the head of this particular governing domain. So, each onset is licensed by 'its' nucleus, while nuclei are licensed either by being (properly) governed by another nucleus or by parameter setting (if they are domain-final). The only nucleus not licensed within a domain is its head.

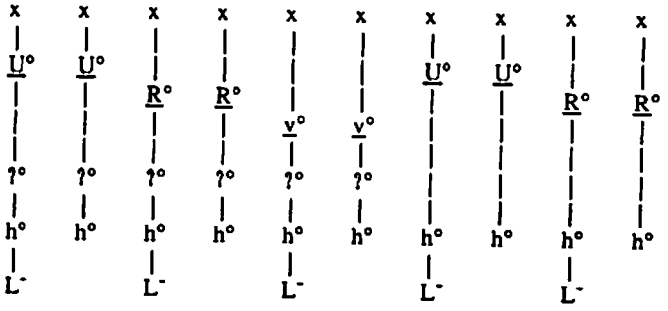
As already observed, the nucleus licensing the onset occupied by the FD obstruent is itself licensed. This reduces its power to license. A licensed empty nucleus, for example, is unable to government-license its onset (see Charette 1990: 242). I would like to suggest that being licensed also affects the degree of segmental complexity which a nucleus can license its onset to have[5]. It appears that there may not be an absolute measure of precisely how complex an onset governed by a licensed empty nucleus can be. Instead, there may just be pressure on segments to decomplexify, with certain language-specific and perhaps some universal constraints determining which elements can delink.

Let me now consider the segmental representations relevant to the present discussion of FD to see what the practical implications of the proposals just put forward are.

The segmental representations of FD obstruents (before and after the application of FD) are shown in (8). Heads of phonological expressions are underlined.

[5]I am grateful to John Harris for this suggestion, which is related to, while still distinct from, Goldsmith's (1989) notion of autosegmental licensing.

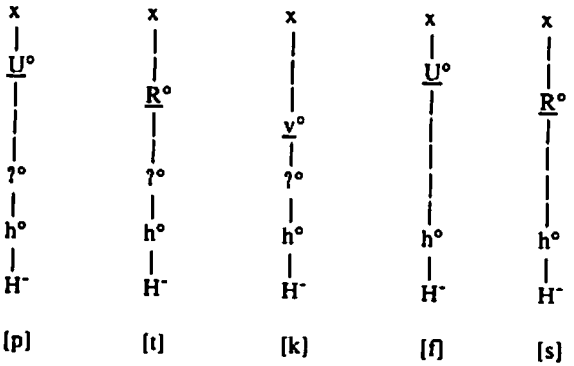
(8)



I would argue that L^- is an element which is easily delinked when a segment is under pressure to decomplexify. As I will show in § 4.2, the occlusion element ?° can also be lost under certain circumstances in some dialects (e.g. Northern Standard German).

The question now arises how non-alternating obstruents are to be represented, that is, those which would traditionally be described as 'underlyingly voiceless'. These are the obstruents which appear as *p, t, k, f* and *β* (or *s* in certain positions) in the German orthography and which featured in the left-hand column of (2). My proposal for these segments is contained in (9). The claim being made here is that H^-, unlike L^-, is not amenable to delinking in German.

(9)



The transcription used in (8) and (9) suggests that the voiceless segments are completely indistinguishable from one another phonetically, in spite of the fact that their phonological representations differ (those which are underlyingly

voiceless contain H^-, while devoiced obstruents lack a laryngeal element). This is not what is intended. It is simply an artifact of the IPA symbols. On the contrary, my analysis predicts that devoiced obstruents (i.e. those which have lost L^-) differ from underlyingly voiceless obstruents (i.e. those with H^-) at all stages of the derivation, including the final output. If this is true, then both phonological and phonetic evidence should be available to support my claim. Indeed, such evidence can be found.

4.2 Phonological evidence

The phonological evidence comes from Northern Standard German (henceforth NSG), a dialect which is relatively similar to *Hochlautung* (the German equivalent of RP). Both dialects use FD in identical ways, except for the fact that speakers of *Hochlautung* appear to restrict the application of FD to environments with parametrically licensed domain-final empty nuclear positions, while NSG speakers also delink L^- before other licensed empty nuclei (see Brockhaus 1990a for discussion). This difference affects only a relatively small set of words.

Another difference between the two dialects which, by contrast with the restriction on FD environments in *Hochlautung* just described, manifests itself throughout the vocabulary consists in the spirantisation of devoiced velar stops in NSG. *Hochlautung* has no general spirantisation processes to speak of[6], but NSG speakers systematically spirantise all those underlyingly voiced velar stops which occur in FD environments. Spirantisation of underlyingly voiceless velar plosives, however, is blocked. This is illustrated in (10), where (a) shows the contrast between the NSG pronunciation of devoiced velar plosives[7] and the corresponding *Hochlautung* pronunciation. The absence of spirantisation for underlyingly voiceless velar stops makes the relevant NSG and *Hochlautung* pronunciations identical, as shown in (b).

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[6]But see Hall 1989b for a Lexical Phonology account of the spirantisation of the velar stop in the suffix *-ig* in *Hochlautung*. In my view, the question of whether this is a genuine phonological process or an artifact of prescriptive grammars merits further investigation. The fact that spirantisation is restricted to this suffix only, with speakers of *Hochlautung* being notoriously unsure about whether to spirantise here or not suggests that we may be dealing with the latter.

[7]Whether a palatal or a velar fricative is chosen as the spirantised reflex of a devoiced velar stop is governed by the same principles as the pronunciation of orthographic *ch*, which has been widely discussed in the literature (see, for example, Hall 1989b and the references there).

(10) (a)

		NSG	Hochlautung
Berg	'mountain'	[bɛrç]	[bɛrk]
Tag	'day'	[tax]	[ta:k]
trug	'(he/she/it) carried'	[tru:x]	[tru:k]
Sog	'suction'	[zo:x]	[zo:k]
lag	'(he/she/it) lay'	[la:x]	[la:k]
Sieg	'victory'	[zi:ç]	[zi:k]
Weg	'path'	[ve:ç]	[ve:k]
Zeug	'stuff'	[tsɔɪç]	[tsɔɪk]

(b)

		NSG/Hochlautung
Werk	'factory'	[vɛrk]
schrak	'(he/she/it) shrank (back)'	[ʃra:k]
buk	'(he/she/it) baked'	[bu:k]
Pik	'spades' (cards)	[pi:k]

Now, if the claim that these spirantisation facts from NSG support my analysis is to have any force at all, then it is incumbent on me to show that this analysis works better than possible alternative accounts of the same facts.

As far as I know, there is no recent account of these particular facts available, but it is easy enough to develop a Lexical Phonology analysis on the basis of published work dealing with related phenomena. I will present such an analysis in this section and contrast it with the GP account outlined above.

There are two rules which need to be included, spirantisation and FD, both of which feature in Hall 1989b. Hall's paper deals with *Hochlautung* only, so the spirantisation rule is restricted to apply to the suffix *-ig* alone (see also fn. 6). It can be adapted for our purposes by changing the environment specification to enable the rule to apply to *all* underlyingly voiced velars appearing in an FD environment. This environment is defined by Hall as being the syllable coda. Both rules apply post-lexically. They are shown in (11).

(11) (a) g-*spirantisation*

$$\begin{bmatrix} -\text{son} \\ +\text{voice} \end{bmatrix} \\ \quad | \\ \quad C \qquad \rightarrow [+\text{cont}] \,/\, \_\_\,]_\sigma \\ \quad | \\ [+\text{high}]$$

(b) *Final Devoicing*

$$[-\text{son}] \rightarrow [-\text{voice}] \,/\, \_\_\,]_\sigma$$

G-spirantisation and FD have to apply in a counterbleeding order to generate the correct output [x]. If FD preceded *g*-spirantisation, i.e. if the rules applied in a bleeding order, *g*-spirantisation would not have access to that part of the derivational history which is crucial for ensuring that only underlyingly voiced velars spirantise, i.e. the [+ voice] specification which is removed by FD. It would, counter-factually, end up being blocked altogether. Now consider the derivation of *Sog* ('suction'), where the two rules apply in the order just established.

(12)

	Sog
	/zo:g/
post-lexical rules	
1. *g*-spirantisation	zo:ɣ
2. Final Devoicing	zo:x
	[zo:x]

The derivation in (12) clearly generates the correct output, [zo:x]. However, it has two disadvantages. The first is a matter of how well-motivated each stage of the derivation is and the other is a question of how constrained a phonological theory should be. Let me begin with the former.

The application of *g*-spirantisation in (12) generates [ɣ]. This makes it abstract inasmuch as [ɣ] never surfaces in NSG[8]. The only velars this dialect permits are [g] (obviously only in non-FD environments), [k] and [x]. In other words, there is no apparent motivation for deriving [ɣ]. A derivation which generated only [k] and [x], both of which are part of the NSG inventory, would be more highly valued.

The second disadvantage of the approach exemplified in (12) is that it relies on extrinsic rule ordering[9]. In order to enable *g*-spirantisation to distinguish velars with an underlying [+ voice] specification from those without, it is necessary to state that *g*-spirantisation precedes FD. As already

[8]There are, of course, northern German dialects which exhibit [ɣ], e.g. in *sagen* ([za:ɣən], 'to say'), such as *Berlinisch*, for example. NSG, however, is not one of them.

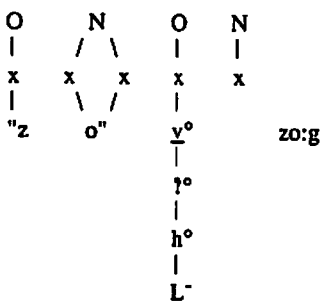
[9]Extrinsic ordering, of course, is only one way of giving a particular rule (*g*-spirantisation in this case) access to crucial parts of the derivational history of a segment. Alternatively, one could have proposed a global rule. This device, however, has, on the whole, been rejected in the literature (see, for example, Kiparsky 1976).

mentioned, this, of course, is also necessary in order to prevent FD from bleeding *g*-spirantisation, which would, counter-factually, generate [k].

Government Phonology does not countenance extrinsic rule ordering, that is, it is more highly constrained than any framework which does. Moreover, the GP analysis of FD to be proposed here can overcome the disadvantages of the Lexical Phonology solution described in the preceding paragraphs. To show how this works, let me attempt to recast the ordered-rule approach illustrated in (12) in terms of the GP framework. To capture the fact that *g*-spirantisation precedes FD, one could propose that only certain segments are subject to the loss of ʔ° (which is how spirantisation would be expressed in GP; see, for example, Harris 1990: 285). These segments would have to contain L^-, which would roughly[10] correspond to the [+ voice] specification mentioned in Hall's *g*-spirantisation rule. To prevent L^- from being delinked before ʔ° (recall that, in my analysis, FD consists in the loss of L^-), one could also stipulate that L^- can only be lost from segments *without* ʔ° (i.e those which have already undergone spirantisation). A possible derivation would then look something like this.

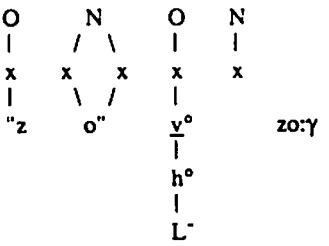
(13) *Sog*

(a)

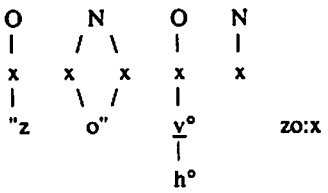


[10]This correspondence is very rough indeed, as the area of overlap between [+ voice] and L^- is quite small. For example, the feature [+ voice] can be associated with vowels, glides and sonorant consonants in a language such as English, whereas L^- cannot. This is only possible in tone languages, where L^- indicates a low tone rather than a voiced sonorant.

(b)



(c)



This solution is seriously flawed. It makes a prediction which is quite strikingly wrong.

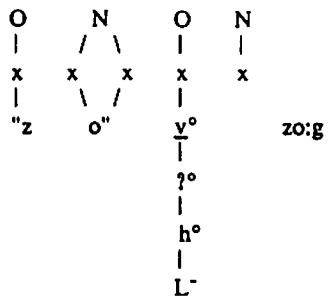
Consider what would happen if spirantisation were to be blocked. In this case, FD could not apply either, because FD takes only segments without ʔ° (i.e those which have already undergone spirantisation) as its input. So, one would expect to hear [g]. Blocking of spirantisation actually occurs when NSG speakers make an effort to conform to the prestige dialect of *Hochlautung* (say, in a formal setting with speakers from different parts of Germany present), but, contrary to what the analysis illustrated in (13) predicts, they use [k] rather than [g] on those occasions. In other words, FD must be able to apply to segments *with* ʔ° in their segmental representations for the correct output to be derived.

This conclusion becomes even more obvious when one takes into account what restricting the loss of L⁻ to segments without ʔ° means for plosives. It means that *no* plosive can undergo FD, as plosives contain ʔ°. To put it differently, FD cannot apply to words such as *gelb* ('yellow') or *Kind* ('child'). This, of course, is quite wrong.

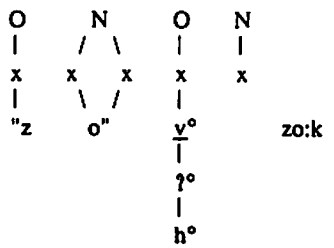
Now consider the alternative account, i.e. that FD precedes spirantisation. The claim would be that obstruents first lose L⁻ and that those velars which have no laryngeal element (i.e. neither L⁻ nor H⁺) can then undergo delinking of ʔ° in FD environments. This is illustrated in (14).

(14) *Sog*

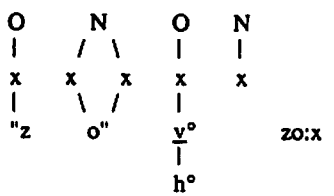
(a)



(b)



(c)



This derivation captures all the facts discussed so far. When spirantisation is blocked, FD can (and does) still apply, yielding [k]. The unattested [ɣ], on the other hand, is generated at no stage in this derivation. L^- can be lost whether ?° is present or not, correctly predicting that both plosives and fricatives undergo FD. The occlusion element ?°, however, can only be delinked if the affected segment is neutral (i.e. contains neither L^- nor H^-), again correctly predicting that /g/ in a non-FD environment (as in *Tage* [ta:gə] 'days', for example) and /k/ fail to spirantise.

The claim that L^- is delinked first receives additional support from the fact that spirantisation of neutral obstruents is attested in languages other than German. T-lenition in English has been analysed along these lines (see Harris & Kaye 1990 and Harris 1990), as has the spirantisation of velars and labials in Greek (Stamatoula Pagoni, p. c.).

So, I propose to treat spirantisation as the second stage in a decomposition process which begins with FD. Only (velar) segments without a tonal element (H^- or L^-) are subject to the loss of ʔ°. And this loss of ʔ° is restricted to the FD environment identified in (6).

4.3 Experimental evidence

The experimental evidence which supports my analysis of FD in the framework of GP was presented in § 3.1, so I will give only a very brief summary of the most important points here.

A number of production studies found that there are statistically significant temporal differences between devoiced obstruents and their underlyingly voiceless congeners. Perception studies carried out in conjunction with the production studies also showed that hearers are able to distinguish between these two segment types, but only to a limited extent. The proportion of correctly identified tokens was consistently better than chance, but probably not sufficiently reliable to be of much use in normal communication.

4.5 The general implications for earlier problems

Some of the problems with the orthodox analysis of FD as [– son] → [– voice] appear to have been resolved by the new analysis in the GP framework. The conflict between the phonological predictions and the production facts no longer exists. The phonological analysis itself makes the claim that underlyingly voiced obstruents differ from their underlyingly voiceless congeners even in FD environments. In other words, there is no need for phonetic implementation rules. In fact, the framework of GP does not recognise a phonetic component. Phonological representations are phonetically interpretable at all levels, so a separate phonetic component would be redundant.

This, however, does not mean that the mismatch between production and perception has disappeared, too. The silver lining of this cloud is that, unlike practically all phonological theories available today, GP does not use primarily articulatory categories to define the phonological elements it employs. Some of the early work in this framework may have given the impression that this was the case (e.g. Kaye *et al.* 1985), but this was mainly a function of the authors'

intention to use widely understood terms (i.e. articulatory features). More recently, there has been a strong move away from the articulatory categories used then and towards acoustically based definitions of the elements of the theory (see especially Lindsey & Harris 1990, also Harris & Lindsey 1991).

In other words, the GP view still maintains the original SPE assumption that the grammar is neutral with regard to the speaker/hearer. At the same time, though, it captures the fact that perception precedes production in language acquisition and that it is with reference to cognitive categories based on sound patterns that the child makes sense of what she hears.

By implication, the prediction is made that the difference between phonologically distinct units has to be perceptually salient for a child to be able to acquire it. The only conceivable exceptions to this must either themselves be part of UG or be deducible from evidence provided by alternations. For example, it may not be necessary for the distinction between a governed (i.e. neutral) obstruent and a governing (charmed) obstruent to be perceptually salient, as charm requirements are contained in UG. Also, some phonological differences may not be perceptually salient in certain environments or may only be salient to a limited extent (such as the difference between a devoiced obstruent and its underlyingly voiceless congener in an FD environment), but the child will be able to establish the phonological distinction by reference to alternation facts, together with her innate phonological 'tool-kit', which, of course, is also part of UG.

The specific claim for FD which I want to make here is that FD belongs to UG. It may not be controlled by its own parameter, but it is conceivable that it is captured by a condition which is parasitic on the parameter which is responsible for determining whether a language parametrically licenses domain-final empty nuclear positions. Only languages which do this (such as English, German, French, Wolof, Catalan, Polish, Russian etc.) have the potential of having FD. So, this condition is probably only activated if the parameter is set to the YES position. In languages where it is not (such as Italian, Japanese, Hawaiian etc.), FD is obviously not an option. However, where the parameter is set to YES, the unmarked case would be for FD to apply.

This claim is supported by the fact that children, when learning a language with domain-final empty nuclear positions, go through a stage of applying FD (usually at the point when final obstruents are first acquired), even in languages where adult speakers don't. Similarly, native speakers of languages which do not parametrically license final empty nuclei characteristically apply FD to foreign words with final obstruents (i.e. words from a language with final empty nuclei), even if the source language does not exhibit FD (see Stampe 1969 (p. 445) for both these points).

5 Conclusion

In this paper I have briefly traced the history of the theoretical construct of neutralisation and examined the role it has played in experimental work over the past decade. I have discussed some issues arising from this experimental work which pose problems for those phonological theories which sparked off the heightened interest in the phonetic aspects of neutralisation. By introducing an analysis couched in the framework of Government Phonology, I have been able to show that it is possible to overcome these problems.

In fact, it seems that neutralisation as such is rapidly disappearing form the phonological landscape. In Lexical Phonology, it has been replaced by structure preservation (which, itself, is being exposed as much less far-reaching and important than originally assumed) and in Government Phonology it has no theoretical status at all.

The only place where neutralisation appears to be truly alive and kicking is in informal use. The one problem with this is that it is not always clear what exactly the speaker means by this term. I hope that this paper can make a contribution here by bringing two possible interpretations of it to the forefront of our minds. Perhaps, being more aware of different ways of looking at it will prevent us from taking our own view for granted. Where neutralisation is concerned, it does seem worth our while beginning a discussion with a definition to avoid getting entangled in a string of misunderstandings.

References

Aitchison, Jean (1987). *Words in the mind: an introduction to the mental lexicon*. Oxford: Blackwell.

Booij, Geert E. & Jerzy Rubach (1987). Postcyclic versus postlexical rules in Lexical Phonology. *Linguistic Inquiry* 18. 1-44.

Borowsky, Toni (1989). Structure preservation and the syllable coda in English. *Natural Language and Linguistic Theory* 7. 145-166.

Brockhaus, Wiebke G. (1990a). Colourful leagues: a Government Phonology approach to final obstruent devoicing in German. *UCL Working Papers in Linguistics* 2. 270-297.

Brockhaus, Wiebke G. (1990b). What is 'final obstruent devoicing': a Government Phonology approach. Paper presented at the 1990 LAGB Autumn Meeting, Leeds.

Bruck, Anthony, Robert A. Fox & Michael W. La Galy (eds.) (1974). *Papers from the parasession on Natural Phonology*. Chicago: Chicago Linguistic Society.

Charette, Monik (1988). Some constraints on governing relations in phonology. PhD dissertation. Montreal: McGill University.

Charette, Monik (1990). Licence to govern. *Phonology* 7.2. 233-253.

Charles-Luce, Jan (1985). Word-final devoicing in German: effects of phonetic and sentential contexts. *Journal of Phonetics* 13. 309-324.

Charles-Luce, Jan & Daniel A. Dinnsen (1987). A reanalysis of Catalan devoicing. *Journal of Phonetics* 15. 187-190.

Chomsky, Noam & Morris Halle (1968). *The Sound Pattern of English*. New York: Harper & Row.

Davidsen-Nielsen, Niels (1978). *Neutralization and archiphoneme: two phonological concepts and their history*. Copenhagen: Akademisk Forlag.

Dinnsen, Daniel A. (ed.) (1979). *Current approaches to phonological theory*. Bloomington: Indiana University Press.

Dinnsen, Daniel A. (1985). A re-examination of phonological neutralization. *Journal of Linguistics* 21. 265-279.

Dinnsen, Daniel A. & Jan Charles-Luce (1984). Phonological neutralization, phonetic implementation and individual differences. *Journal of Phonetics* 12. 49-60.

Fay, David & Anne Cutler (1977). Malapropisms and the structure of the mental lexicon. *Linguistic Inquiry* 8. 505-520.

Fourakis, Marios & Gregory K. Iverson (1984). On the 'incomplete neutralization' of German final obstruents. *Phonetica* 41. 140-149.

Goldsmith, John A. (1989). Licensing, inalterability and harmonic rule application. *CLS* 25. 145-157.

Hall, Tracy Alan (1989a). German syllabification, the velar nasal, and the representation of schwa. *Linguistics* 27. 807-842.

Hall, Tracy Alan (1989b). Lexical phonology and the distribution of German [ç] and [x]. *Phonology* 6. 1-17.

Halle, Morris & Kenneth N. Stevens (1971). A note on laryngeal features. *Quarterly Progress Report of the Research Laboratory of Electronics, MIT*. **101**. 198-213.

Harris, John (1987). Non-structure-preserving rules in Lexical Phonology: southeastern Bantu harmony. *Lingua* 73. 255-292.

Harris, John (1989). Towards a lexical analysis of sound change in progress. Journal of *Linguistics* 25. 35-56.

Harris, John (1990). Segmental complexity and phonological government. *Phonology* 7.2. 255-300.

Harris, John & Jonathan D. Kaye (1990). A tale of two cities: London glottalling and New York city tapping. *The Linguistic Review* 7.3.

Harris, John & Geoffrey A. Lindsey (1991). Putting the phon back into phonology. Paper presented at March 1991 London Phonology Seminar.

Houlihan, Kathleen & Gregory K. Iverson. (1979). Functionally-constrained phonology. In Dinnsen (1979). 51-73.

Hulst, Harry G. van der & Norval S.H. Smith (eds.) (1982). *The structure of phonological representations*. 2 vols. Dordrecht: Foris.

Jassem, Wiktor & L. Richter (1989). Neutralization of voicing in Polish obstruents. *Journal of Phonetics* 17. 317-325.

Kaisse, Ellen M. & Patricia A. Shaw (1985). On the theory of Lexical Phonology. *Phonology Yearbook* 2. 1-30.

Kaye, Jonathan D. (1990). 'Coda' licensing. *Phonology* 7.2. 301-330.

Kaye, Jonathan D., Jean Lowenstamm & Jean-Roger Vergnaud (1985). The internal structure of phonological elements: a theory of charm and government. *Phonology Yearbook* 2. 305-328.

Kaye, Jonathan D., Jean Lowenstamm & Jean-Roger Vergnaud (1990). Constituent structure and government in phonology. *Phonology* 7.2. 193-231.

Kiparsky, Paul (1976). Abstractness, opacity, and global rules. In Koutsoudas (1976). 160-186.

Kiparsky, Paul (1982a). From cyclic phonology to lexical phonology. In van der Hulst & Smith (1982: vol.1). 131-176.

Kiparsky, Paul (1982b). Lexical Morphology and Phonology. In The Linguistic Society of Korea (ed.) (1982). *Linguistics in the morning calm*. Seoul: Hanshin. 3-91.

Klatt, Dennis H. (1981). Lexical representations for speech production and perception. In Myers *et al.* (1981). 11-31.

Kohler, Klaus J. (1984). Phonetic explanation in phonology: the feature fortis/lenis. *Phonetica* 41. 150-174.

Koutsoudas, Andreas (ed.) (1976). *The application and ordering of grammatical rules*. The Hague: Mouton.

Lindsey, Geoffrey A. & John Harris (1990). Phonetic interpretation in generative grammar. *UCL Working Papers in Linguistics* 2.

Mascaró, Joan (1987). Underlying voicing recoverability of finally devoiced obstruents in Catalan. *Journal of Phonetics* 15. 183-186.

Myers, Terry, John Laver & John Anderson (eds.) (1981). *The cognitive representation of speech*. Amsterdam: North-Holland.

Newmeyer, Frederick J. (ed.) (1988). *Linguistics: the Cambridge Survey*. Vol. 1: Linguistic theory: foundations. Cambridge: Cambridge University Press.

O'Dell, Michael L. & Robert F. Port (1983). Discrimination of word-final voicing in German. *Journal of the Acoustical Society of America* 73, Suppl. 1. S31.

Ohala, John J. (1974). Phonetic explanation in phonology. In Bruck *et al.* (1974). 251-274.

Port, Robert F. & Crawford, Penny (1989). Incomplete neutralization and pragmatics in German. *Journal of Phonetics* 17. 257-282.

Port, Robert F. & Michael L. O'Dell (1985). Neutralization of syllable-final voicing in German. *Journal of Phonetics* 13. 455-471.

Port, Robert F., Fares Mitleb & M. L. O'Dell (1981). Neutralization of voicing in German is incomplete. *Journal of the Acoustical Society of America* 70, Suppl. 1. S13.

Pulleyblank, Douglas G. (1986). *Tone in Lexical Phonology*. Dordrecht: Reidel.

Rubach, Jerzy (1990). Final devoicing and cyclic syllabification in German. *Linguistic Inquiry* 21. 79-94.

Slowiaczek, Louisa M. & Daniel A. Dinnsen (1985). On the neutralizing status of Polish word-final devoicing. *Journal of Phonetics* 13. 325-341.

Stampe, David (1969). The acquisition of phonetic representation. *CLS* 5. 443-454.

Trubetzkoy, N.S. (1939). *Grundzüge der Phonologie*. English version, trans. C.A.M. Baltaxe (1969). *Principles of Phonology*. Berkeley: University of California Press.

Vennemann, Theo (1968). German phonology. PhD dissertation. Los Angeles: UCLA.

Vennemann, Theo (1972). On the theory of Syllabic Phonology. *Linguistische Berichte* 18. 1-18.

Vennemann, Theo (1988). *Preference laws for syllable structure and the explanation of sound change*. Berlin: Mouton de Gruyter.