Incomplete Devoicing in Formal Phonology

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1 Incomplete Final Devoicing

The phonological process of final devoicing is shared by many languages.[1] The following example presents a few well-known cases:

(1) a. Catalan:
   i. *gris* 'grey (M)' - *grizə* 'grey (F)'
   ii. *gos* 'dog (M)' - *gosə* 'dog (F)'
   b. Dutch:
   i. *kwaa[t]* 'angry (PRED.)' - *kwadə* 'angry (ATT)'
   ii. *laat* 'late (PRED.)' - *latə* 'late (ATT)'
   c. German:
   i. *blin[t]* 'blind (PRED.)' - *blində* 'blind (ATT)'
   ii. *bunt* 'colourful (PRED.)' - *buntə* 'colourful (ATT)'
   d. Polish:
   i. *klup* 'club' - *klubi* 'clubs'
   ii. *trup* 'corpse' - *trupi* 'corpses'
   e. Russian:
   i. *knik* 'book (GEN.PL.)' - *kniga* 'book (NOM.SG.)'
   ii. *sok* 'juice (NOM.SG.)' - *soka* 'juice (GEN.SG.)'

[1]Thanks are due to Ricardo Bermúdez-Otero, Ben Hermans, Glyn Piggot, Anthi Revithiadou and Tobias Scheer for useful comments. All disclaimers apply.

The examples in (i) give an alternating pair: a voiceless obstruent at the end of a syllable (in all these cases actually at the end of the word) shows up as voiced when it occurs with an inflectional suffix starting with a vowel — in other words, if it appears in an onset. The examples in (ii) show that this voicing alternation cannot be due to intervocalic voicing, since there are other words ending in voiceless obstruents which do not show a similar alternation.

Interestingly, for all of the languages in (1), it has been claimed in the literature that final-devoicing is phonetically incomplete: the neutralisation is not completely lost, but recoverable in fine-grained phonetic detail.

This incomplete neutralisation is cited by Port and Leary (2005) as evidence 'against formal phonology'. They claim (p.948-949):

> The key fact [...] is that these word pairs lack an essential property of any symbol token [...]: they are neither discretely different nor are they the same. [...] It is interesting and probably important that all of the cases of incomplete neutralization mentioned are context-sensitive. That is, they do not represent a general collapse of a distinction in the lexicon. In certain contexts, a distinction has been largely lost, but whatever 'process' achieves the neutralization does not completely wipe out the effects of an 'underlying spelling' of the lexical items. These cases present troublesome violations of the claim that the phonetics of languages is based on a discrete or digital inventory, and that these discrete phonetic units function like the tokens of a formal system. Instead, speakers can occasionally leave a distinction only partially neutralized by using fine articulatory control.

This assumed lack of success of formalist theories to account for the 'in-between' status of neutralised segments, in combination with a few other arguments, leads Port and Leary (2005) to discard any attempt to get to a theory of phonology which is based on a finite alphabet of formal symbols.

I argue in this article that incomplete neutralisation does *not* constitute an argument against formalist theories of phonology. It may constitute an argument against theories of the type proposed in Chomsky and Halle (1968) to which Port and Leary (2005) refer, but this is due to the fact that such theories are based on a view of phonological representations that is too simplistic. I argue that a theory of final devoicing such as proposed in Kooij and van Oostendorp (2003); van Oostendorp (in press), combined with a reasonable Optimality-Theoretic theory of input-output relations as proposed in Prince and Smolensky (1993) and elaborated in van Oostendorp (to appeara,t); Revithiadou (to appear) is sufficiently strong to deal with these facts without any extra ground-breaking assumptions.

2 The puzzle: Incomplete final devoicing

It is fair to say that by now there is a fairly substantive literature on the phonetics of final devoicing, and that a large proportion of this literature has shown that this devoicing is incomplete. Even if native speakers will claim that they hear a voiceless obstruent, or will judge that a word ending in a devoiced obstruent rhymes with a word ending in a voiceless obstruent, there are still two types of indications that the devoicing has not been absolute. The first is that subtle phonetic measurements may still reveal a systematic difference; the second is that in certain types of psycholinguistic tests, native speakers are still able to show a sensitivitiy to these phonetic subtleties. For instance, if asked to randomly guess whether a given instance [rat] corresponds to (German) /rad/ 'wheel' or /rat/ 'rat', speakers will guess correctly at a higher than chance level (60 to 70 per cent, according to Port and Crawford, 1999).[2] Port and Leary (2005) observe: "If [these words] were the same, then in a listening task you would expect 50 percent correct (pure guessing - like English *too* and *two* would show). If contrastive, one would expect at least 99 percent correct identification under good listening conditions with motivated subjects (just like [German] *Bunde* and *bunte* would show)." Neither is the case.

Previous phonetic results about incomplete neutralisation have suffered from methodological criticisms. For instance, it has been claimed (Fourakis and Iverson, 1984; Baumann, 1995; Manaster Ramer, 1996) that these results were obtained in a laboratory situation in which the orthography — reflecting the 'underlying' distinction — played a role which was larger than in 'real life' situations, or in labs that were based in the United States with (almost) bilingual speakers so that we could expect influence from non-devoicing English.

However, it has also been pointed out (see Charles-Luce, 1993; Jansen, 2004, for an overview) that not all experiments suffered from these problems. Furthermore, some of the more recent literature has repaired these criticisms, and still reached the same conclusions. There is thus no reason to discard them, and furthermore we also cannot say that these facts are 'mere phonetics', since they reflect a voicing distinction that is undoubtedly underlying, hence phonological, and a process that is also phonological at least in some cases. For instance, it interacts with phonological processes of voicing assimilation and/or it stands in a counterbleeding relation with resyllabification across morpheme boundaries in Catalan, Polish and Dutch. An example of

[2] Among the relevant literature, we mention Dinnsen and Charles-Luce (1984); Charles-Luce and Dinnsen (1987); Wheeler (2005) for Catalan; Ernestus (2000); Warner et al. (2004); Ernestus and Baayen (To appear,t) for Dutch; Dinnsen and Garcia-Zamor (1971); Mitleb (1981); Dinnsen and Charles-Luce (1984); Port and O'Dell (1985); Piroth et al. (1991) for German; Slowiaczek and Dinnsen (1985); Slowiaczek and Szymanska (1989) for Polish; Pye (1986) for Russian; Wilson (2003) for Turkish.

the latter is that Dutch vowel-initial enclitics trigger resyllabification of the stem-final consonant, which nevertheless remains voiceless, even if it is no longer in an onset at the end of the word, or in the phonetics (Booij, 1995)

(2) a. *ik heb* 'I have' [ɪk hɛp]
b. *hebben* 'to have' [hɛ.bən]
c. *ik heb 'm* 'I have him' [ɪk hɛ.pəm]

Finally, it seems to me that a model of linguistic competence might still want to account for the fact that listeners are able to perceive the very subtle and subconscious phonetic details in the first place.

Furthermore, these results are not necessarily incompatible with accounts based on categorical delaryngealisation. In the literature, we can already find roughly two ways of dealing with them, both of which can be worked out in a variety of ways (cf. Bermúdez-Otero, 2006):

1. There is a phonetic paradigmatic effect (Ernestus and Baayen, to appear); the phonetic implementation of words ending in a voiced obstruent is influenced by the fact that the same word is pronounced with a voiced obstruent in other positions in the paradigm. 'Word-based phonetics' (Pierrehumbert, 2002) is a possible implementation of this.
2. The laryngeal contrast between voiced and voiceless obstruents is 'enhanced' by other features (or for instance by vowel length) before it disappears. A well-known implementation is the one by Rice and Avery (1989).

Although both these accounts are feasible, they both assume a complication of the model of phonology-phonetics interaction, if the null hypothesis is that phonology is free of phonetic substance, and inversely, phonetics blindly interprets the structures that are generated by the phonology. Under the first solution, the phonetics is not blind, but can independently access word structure. Under the second proposal, the phonology already takes care of the 'enhancement' that would otherwise be considered purely phonetic.

It is clear why solutions such as these have been proposed, and it is also clear why some authors have concluded from these facts that formal theories of phonology are incompatible with incomplete neutralisation. We will need a phonological (surface) structure in which devoiced segments do not carry the feature [voice] but still differ from underlyingly voiceless segments. This seems *prima facie* strange, but it is not a logical impossibility, given an appropriate theory of phonological representations, as we will now show.

3 Turbidity theory as a theory of faithfulness

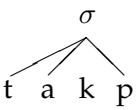
The set of Optimality Theoretic constraints is usually divided into two subsets: markedness and faithfulness. Markedness constraints evaluate the output representations, and check for instance whether feet are binary, syllables have onsets, and vowels do not contain undesirable feature combinations such as [-back, +round]. Faithfulness constraints on the other hand check whether the output representation has not changed from the input.

In the literature, we can discern two traditions in the formalisation of faithfulness constraints. One tradition works with separate input and output representations, and correspondence relations betweeen them; it is fair to say that most work in OT, following McCarthy and Prince (1995), falls within this tradition. An alternative tradition, however, is based on the notion of *Containment* (Prince and Smolensky, 1993):

(3) *Containment.* Every element of the phonological input representation is contained in the output. (There is no deletion.)

In a Containment model of faithfulness, all constraints only evaluate one representation, the output. Since the input is *contained* in this output, it does not need a separate status in the model. An important question is of course how we represent non-pronunciation in such a model. The answer which Prince and Smolensky (1993) provide is that underlying elements which are not parsed are left unpronounced. Thus, suppose that in a hypothetical language we have an input /takp/, and that this input is pronounced in isolation as [tap]. We may picture the output representation as follows:

(4)



Only /t, a, p/ are parsed into the syllable structure, and therefore into higher-order phonological structure. Constraints against 'deletion' in this theory of faithfulness are constraints against floating material: PARSE constraints (e.g. 'a segment needs to be parsed into a syllable'). Furthermore, it is assumed that the phonetics will only interpret the material which is parsed into the prosodic hierarchy: it is subject to a principle of Stray Erasure (Itô, 1986):

(5) *Stray Erasure*: The phonetics only interprets parsed phonological material.

Prince and Smolensky (1993) have implemented the idea of Containment in one specific way, the so-called PARSE & FILL Model, named after the two constraints which take care of the most important aspects of faithfulness theory, deletion and insertion respectively:

(6) a. PARSE: Deleted elements are 'not parsed' in the phonological structure
b. FILL: Inserted segments are 'empty'

The PARSE & FILL Model suffers from a number of problems (van Oostendorp, to appeara), which mainly are related to its theory of epenthesis. Inserted segments have to be 'empty' in order to be recognizable as inserted at all: if we would allow non-empty epenthetic segments, the constraint FILL would not be violated, and hence we would have no theoretical device to prevent gratuitous epenthesis in all languages of the world. We thus have to prevent features from being inserted or from spreading into epenthetic vowels if we use FILL. This means for instance that we can have no phonological analysis of vowel harmony to epenthetic vowels, clearly an undesirable result.

Instead of this particular implementation of Containment, (van Oostendorp, to appeara) therefore proposes an alternative implementation, which is based on the principle of Consistency of Exponence, another classic principle constraining Gen in Optimality Theory:

(7) *Consistency of Exponence*
"No changes in the exponence of a phonologically-specified morpheme are permitted." (McCarthy and Prince, 1993, 1994)

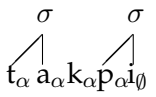
This principle, assumed to restrict Gen, was explained by McCarthy and Prince (1993, 1994) in the following way:

> "[Consistency of Exponence] means that the lexical specifications of a morpheme (segments, prosody, or whatever) can never be affected by Gen. In particular, epenthetic elements posited by Gen will have no morphological affiliation, even when they lie within or between strings with morphemic identity. Similarly, underparsing of segments — failure to endow them with syllable structure — will not change the make-up of a morpheme, though it will surely change how that morpheme is realized phonetically. Thus, any given morpheme's phonological exponents must be identical in underlying and surface form."

An important consequence of this principle is that the morphological identity of segments will be visible at the surface structure; in this way our phonological constraints can refer to them even within a monostratal model.

van Oostendorp (to appeara) proposes a notation which allows us to see the effects of Consistency of Exponence, and which is based on the metaphor of colouring. It is assumed that every morpheme has its own 'colour' which has been provided by the lexicon and which is distributed over all segments and other material — features, mora's, etc. — which is lexically present

in that morpheme. Assume for instance that we have an input morheme /takp/, and an output candidate which would be pronounced ad [tapi]. This candidate would look as follows in the phonological surface (for the sake of reproductional convenience, the colours are reproduced here as subscripts):

(8)


In this simple example, there is only one morpheme with the 'colour' α. The epenthetic segment does not have any morphological colour, which denoted here by giving $\emptyset$ as its subscript. In terms of colours, Consistency of Exponence states that Gen cannot give colour to epenthetic material, and it cannot alter the colours of underlying material.[3]

(9) *Consistency of Exponence* (Colour-based version). Gen cannot change the morphological colour of any phonological element.

But given this notational assumption, it becomes easy to determine the status of epenthetic material by checking only the phonological output: epenthetic material is exactly the material which does not have a morphological colour. Epenthetic segments thus do not have to be marked as featurally empty, since they are already 'empty' from a morphological perspective by definition. It now becomes possible to do away with FILL and to define constraints against epenthesis and deletion in a parallel fashion. Deletion means — like in the PARSE&FILL model — that a segment is not incorporated into the phonological structure; epenthesis means that a segment is not incorporated into the morphological structure.

(10) a. PARSE-$\phi(\alpha)$: The morphological element α must be incorporated into the phonological structure. (No deletion.)
b. PARSE-$\mu(\alpha)$: The phonological element α must be incorporated into the morphological structure. (No insertion.)

van Oostendorp (to appeara) argues that a large portion of the OT literature — also if it overtly is based on the theory of correspondence — has to assume Consistency of Exponence, for instance in order to implement

[3]Ricardo Bermúdez Otero (p.c.) and an anonymous reviewer have both raised the question of how this relates to the traditional notion of Bracket Erasure, used to account for cyclic effects. The answer to this will depend on one's view of cyclicity. (Coloured) Containment is not incompatible with a view in which phonology interacts with morphology in a cyclic way. Even if Gen cannot change colours, this does not mean that Bracket Erasure cannot be applied: when the output of one cycle becomes the input of the next cycle, internal colours may be lost.

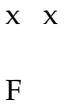
morphologically-based positional faithfulness. If that is true, the constraints in (10) come for free, as it were.

However, we still have not implemented a full theory of faithfulness for features, given these assumptions. In particular we still need to find a way to describe the deletion of underlying features. Suppose we have the following input: ('x' is a root node, an X-slot, a mora, or whatever is the host for a phonological feature; 'F' is the feature itself):

(11)

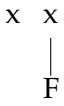
Furthermore, suppose that x is not pronounced with the feature F in the phonetics. What should be the corresponding output representation? Obviously, F cannot be deleted, and the fact that it is not pronounced could be interpreted as it not being associated to the segment. We could thus assume that the following is the relevant output representation:

(12)



Yet there is a problem with the theory of feature faithfulness we have now developed. Suppose that PARSE-F is ranked very highly in some language L. (11) will then be favoured over (12) in L. But how about (13)?

(13)



There is nothing in the Containment model so far which distinguishes these two representations. We have to implement the insight that also the association line should be preserved from the input to the output: we cannot just 'move' the association line from one segment to the next one. But it does not seem to make ontological sense to say that association lines can also be 'parsed' or 'not parsed' by Gen: an association line is not a phonological object on a par with features and segments, but it rather describes a relation between two phonological objects.

In order to solve this problem, Revithiadou (to appear) revises an idea originally put forward by Goldrick (2000), called Turbidity Theory. In this theory, autosegmental association lines are replaced by two types of relations:

- *projection*: an abstract, structural relationship holding between a segment and the feature (roughly equivalent to notions of 'Licensing').

- *pronunciation*: an output relationship that holds between the feature and the segment and describes the output realization of structure.

The representations are 'turbid' because the projection relations are not pronounced; they serve purely structural needs. For Goldrick (2000), their main function is the description of phenomena which are somehow opaque. For instance, in Luganda — like in many other languages — deletion of a vowel in hiatus may lead to lengthening of the vowel that is left behind.

(14) a. /ka+tiko/ → [katiko] 'mushroom'
b. /ka+oto/ → [ko:to] 'fireplace (DIM)'
c. /ka+ezi/ → [ke:zi] 'moon (DIM)'

The standard analysis of this would be that the deleted vowel leaves behind its mora which is filled by the other vowel, which thus becomes bimoraic, i.e. long. The question is, where does this mora come from? It is not necessarily underlying, since nothing is in OT: given Richness of the Base, vowels can be underlyingly moraless, but still they will always have this effect. The answer of Turbidity Theory to this puzzle is that the mora is *projected* by the deleted vowel, in spite of the fact that this deleted vowel is itself not pronounced; however the mora is *pronounced* on the vowel which is itself pronounced. The turbid representation of the relevant vowel pair in (14b) is as follows:

(15)

The upward arrow represents the projection relation: the first mora is present because the /a/ wants it to. The downward arrow represents the pronunciation relation: the first mora is pronounced on the [o] vowel. The second mora is both projected and pronounced by this second vowel; this is the unmarked state of affairs, and there will hence be constraints requiring pronunciation and projection to match (RECIPROCITY, see below).

Notice that Turbidity Theory presupposes Containment: this view of relations between vowels and features or mora's does not make a lot of sense if the original vowel /a/ is lost, because in that case it also will not enforce projection of a mora. Turbidity Theory also requires a slight modification of the principle of Stray Erasure in (5), at least for subsegmental material:

(16) *Stray Erasure* (Turbid version): The phonetics only interprets features that stand in a pronunciation relation to a segment in the phonology.

However, notice that in its present version, Turbidity Theory does not really solve the original problem, which is how faithfulness constraints can differentiate between the representations in (11) and (13) (imagine that the lines

given here are pairs of projection and pronunciation relations). In Goldrick (2000)'s original version, there is still no way to keep track of what is underlying, and what is not underlying. This is where Revithiadou (to appear)'s extension of the theory becomes important. She proposes that

> we take projection lines to represent the lexical state of affairs, that is, to be part of the lexical representation of a morpheme [...]. In conformity with [Consistency of Exponence], therefore, they cannot be altered by Gen.

We thus assume that projection lines represent the influence of the lexicon on the autosegmental phonology: Gen can neither insert nor delete lexical material, hence it simply cannot change projection lines, but it can freely manipulate pronunciation lines.[4] Since there are constraints matching projection and pronunciation lines, however, — of the type in (17), adapted from Goldrick (2000)'s and Revithiadou (to appear)'s work — usually a feature will be sent to the phonetics on the segment on which it is specified in the lexicon. But 'deletion' of a feature will usually be represented by a projection line which is *not* interpreted as a pronunciation line:

(17) RECIPROCITY$^{V}{}_{F}$ ($\mathscr{R}^{V}{}_{F}$): If a vowel V entertains a *projection* relation with a feature F, then F must entertain a *pronunciation* relation with the vowel V.

(18)

The constraint in (17) is a markedness constraint: it checks uniquely on the output whether certain lines match other lines. But given that projection lines are inalterable, it also plays the role of faithfulness, making sure that lexical relations will also interpreted by the phonetics.[5]

4 The analysis of final devoicing

In the analysis of final devoicing, we have to make a number of analytical choices, for instance regarding the representation of the laryngeal contrast —

[4] See Eychenne (2006) for a proposal as to how the distinction between pronunciation and projection relations could be grounded in the phonetics; Blaho and Bye (2005) present a similar idea in terms of Correspondence Theory.

[5] Notice that we are departing from Goldrick (2000)'s view, under which projection lines can crucially be altered, in particular for prosodic structure, such as mora's and syllables. We will not delve into the fine-grained structure of differences in faithfulness between subsegmental structure and prosody here, but notice that it is often assumed that syllable structure is different to different faithfulness requirements than segmental structure, if only because there seems to be no language which lexically contrasts monomorphemic V.CV from VC.V by way of syllable structure only.

which features are involved, are these features binary or monovalent, etc. —, or the precise context — end of the syllable, end of the word, etc. (see the contributions to van der Torre and van de Weijer, in press, for an overview of such possibilities for Dutch). It is also possible that different analytical tools are needed for different languages showing final devoicing.

The precise formulation of the relevant constraints obviously falls outside of the scope of the study of faithfulness and hence of this paper: these will be pure markedness constraints. Our proposals are independent of them. In order to make our proposal maximally explicit, we will use the following constraint (Lombardi, 1991, 1999, for more details):

(19) FINDEV
[voice] cannot entertain a pronunciation relation with an obstruent in the coda.

Furthermore, I will assume for the sake of concreteness that [voice] is a monovalent feature, contra Wetzels and Mascaró (2001): an obstruent has a [voice] feature, or it does not have it. In other words, for the Dutch adjective *kwaad* 'angry', ending in an underlying [voice] there are two relevant potential realisations: one in which the feature standing in a projection relation is also pronounced, and one in which the pronounciation relation is not realised. The latter is the devoiced representation:

(20)

a. [kwaːd̥]	b. [kwaːd]
k w aː d ↑ voice	k w aː d ↕ voice

FINDEV will prefer the latter one, but the former will be preferred by RECIPROCITY$^{V}{}_{F}$, so that we have a miniature typology:

(21) a. FINDEV≫RECIPROCITY$^{V}{}_{F}$: Final Devoicing (Catalan, Dutch, etc.)

/kwaːd/	FINDEV	RECIPROCITY$^{V}{}_{F}$
kwaːd	*!	
☞kwaːd̥		*

b. RECIPROCITY$^{V}{}_{F}$≫FINDEV: Final Devoicing (Spanish, English, etc.)

/kwaːd/	RECIPROCITY$^{V}{}_{F}$	FINDEV
☞kwaːd		*
kwaːd̥	*!	

The reader will have noticed already that given the phonological apparatus introduced for independent reasons so far we actually have a phonologi-

cal surface structure which is transcribed more accurately as [kwa:d̥] than as [kwa:t]. An underlyingly voiceless segment will have a different phonological representation, viz. one in which [voice] is completely absent.[6]

Given the interpretation given to *Stray Erasure* in (16) above, this phonological difference does not have an effect in the phonetics. What the facts of incomplete neutralisation in section 2 suggest, then, is that this interpretation may be too rigid. In some cases, also features which are only projected play a role in the phonetic interpretation. For instance, if the length of the preceding vowel is a cue to voicing, this lengthening may be triggered slightly by projected voicing features as well. Of course, it is required that the phonetics is no longer categorical, but gradient: it will interpret the phonological [d̥] in a number of very subtle ways, whereas phonological [d] and [t] get a more stable — yet also still gradient — interpretation. Yet I believe there is nothing exotic about the assumption that the phonetics is no longer a categorical system.

Notice that this model is able to maintain a classical view of the relation between phonology and phonetics. Phonology is free of phonetics: the difference between projection and pronunciation lines was introduced for completely independent reasons, viz. to describe phonological opacity, and it is the only phonological device we need to describe the difference between devoiced and voiceless. There is no introduction of 'enhancing' features in the phonology. Phonetics, inversely, still does not need to 'know' anything apart from the phonological surface structure: it does not need to refer to the lexicon directly, since it gets all the lexical information it needs from the phonological surface.

5 Concluding remarks

The debate about 'functionalism' vs. 'formalism' has been revived in recent years, but it has been conducted in a manner which might be called one-sided: in a number of works, 'functionalists' have been pointing out facts which they consider to be problematic for formalist views of phonology.

We have to point out that the reverse — finding facts which are hard to account for in a functionalist view is inherently more difficult, since such a view seems inherently less restrictive, at least in as far as we do not have an explicit theory of possible 'functions' of language, and of possible ways in which these functions can be worked out. The article 'Against formal phonology' by Port and Leary (2005), cited earlier, for instance, does not present a

[6] This raises the question what happens in languages without any voicing contrast on obstruents. Given Richness of the Base, we should still posit underlyingly voiced segments in such a language, which would then give small but systematic phonetic cues as to the presence of voicing. Presumably, learnability requirements will make sure that such hypothetical inputs with a phonologically inactive and phonetically hardly discernible voicing will not make it into the lexicon.

detailed alternative proposal: it attacks a school of thought without replacing it with something which has the same level of explicitness. In the absence of such an alternative, it is hard to even think of potential data which would falsify the 'functionalist' view (what is a logically possible fact which can be 'proved' dysfunctional?).

Given this, a typical 'formalist' response to the functionalist challenge has been to point out problems with the data, or to ignore those data completely. I have argued in this article that the evidence for incomplete neutralisation seems too convincing to completely ignore it; it sheds light at least on the interface between phonology and phonetics. The fact that most speakers are not able to consciously hear the difference between a devoiced stop and an underlyingly voiceless one, does not count as sufficient evidence: phonology is not (just) about conscious judgements, but about any kind of way in which categorical distinctions play a role in linguistic behaviour. Just delegating these facts to the phonetics will mean that the phonetics gives access to many types of information which is purely lexical — and in a way this may vindicate the functionalist position: if the phonetics can see all this information anyway, why would we need the phonology to manipulate them as well?

Formal phonologists thus need to take these facts seriously, and try to incorporate them into their model of phonology. The more conservative approach is to *not* give up the whole enterprise of formal analysis in the face of a few problematic data, but try to incorporate the apparent recalcitrant facts without making the system too flexible so as to be no longer falsifiable. An additional problem is that functionalists often argue against fairly simplistic formal models, such as those presented — almost 40 years ago — by Chomsky and Halle (1968). In this article I have shown how the facts of incomplete devoicing can be incorporated into a purely formal as well as fairly elegant and simple theory of phonological representations in which we can represent that two categories ([d̥] and [t]) are "neither discretely different nor are they the same", in the words of Port and Leary (2005). If we accept that it is better to have an explicit theory of a phenomenon, and that simpler theories are preferable over more complex ones, this means that incomplete devoicing seems an argument in favour of formal phonology rather than against it.

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