Rethinking (t,d).

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Rosalind A. M. Temple
University of Oxford
rosalind.temple@new.ox.ac.uk

Abstract

Tagliamonte and Temple (2005) describes an attempt to replicate on a variety of British English some of the many and varied North American studies of the sociolinguistic variable known inter alia as '-t,d deletion' or 'coronal stop deletion', that is the variable deletion of word-final /t/ or /d/ in two-consonant clusters (e.g. post pronounced variably as [pəʊst] or [pəʊs]). The results of that study were not entirely compatible with previous accounts and could not be explained away by reference to extra-linguistic variables. The present paper investigates alternative explanations of the apparent incompatibility of the British and North American findings by exploring further some of the methodological and analytical questions raised Tagliamonte and Temple's study, but which the authors were not able to address or develop explicitly in that paper. These considerations raise some serious challenges for the Lexical Phonology account of (t,d) in particular and for phonological accounts of the variable in general, and their implications for how this much-studied variable is characterised are explored.

"The point is that we need to reconsider the nature of the constructs upon which our descriptions are based and how these notions relate to the methodological, descriptive, and explanatory goals that motivate variation studies" Wolfram (1991:31).

1. Introduction[1]

Phonological variable rules were originally conceived within the context of generative phonology (e.g Labov, 1969), although much of their subsequent development has run independently from that of phonological theory. Nevertheless, variationists sought from the outset to relate their findings to developments in general theory, and in recent decades both theoretical and laboratory phonologists have begun to take a greater interest in variationist studies (see, e.g. Coetzee & Pater 2011, Coetzee 2012). Variationists have in turn adopted developments in analytical acoustic techniques, for example, formant analysis has largely replaced scalar auditory classifications of vowel quality, and automatic data processing techniques have permitted the analysis of larger quantities of data than ever before. Over the same period, developments and refinements of articulary techniques have been harnessed by phonologists, notably under the Laboratory Phonology umbrella, and the term

[1] My gratitude continues for Sali Tagliamonte's generosity in inviting me to collaborate with her after I expressed an interest in her preliminary findings on (t,d) and for the stimulating exchanges we have had since then. Although we have of course discussed many of the questions in the present paper, the analyses and opinions expressed here are my own and not all shared by her, so she should not be called to account for them. I am also grateful to Sali for access to data collected with the support of the Economic and Social Research Council of the United Kingdom (ESRC) under Research Grant #R000238287, *Grammatical Variation and Change in British English: Perspectives from York*. Many other colleagues have provided encouragement and stimulating discussion, most particularly John Coleman, but also Ricardo Bermúdez-Otero and audiences at the First International Conference on the Linguistics of Contemporary English in Edinburgh, at UKLVC 5 in Aberdeen and at the Advances in Sociophonetics workshop in Pisa in 2010. A preliminary version of this paper has appeared in *Oxford University Working Papers in Linguistics, Philology and Phonetics* (Temple, 2009), and I am grateful to the editors of that volume and to the anonymous reviewers of the present version for their helpful comments.

'sociophonetics' has emerged as these have been brought to bear on variationist studies. Sociophonetic studies have brought new insights into the nature and progression of sound changes (e.g., Lawson et al 2011) but their implications for the descriptive and analytical constructs at the heart of variationist phonology have yet to be fully explored[2]. This paper presents a case study of one of the most extensively studied variable rules in English, coronal stop deletion or "(t,d)" (e.g. Labov et al 1968, Wolfram 1969, Guy 1977, Bayley 1995, Hazen 2011) , highlighting some limitations of the widely used analytical method of auditory-impressionistic transcription (even when accompanied by visual inspection of acoustic waveforms or spectrograms), their implications for the modelling of (t,d) as a variable phonological rule, and the imperative for studies of variables such as this to revisit the constructs on which such rules are based. Where there is a solid, independent case for still treating them as phonological rules governing alternation between a set of discrete variants, all well and good, but with (t,d) that case is less solid than would appear from the literature (see discussions below). The combined evidence from the (selective) qualitative observations and the distributional data presented here suggest that it would be profitable to revisit the basic units of analysis in the light of both methodological developments and what is known about the behaviour of other word-final codas, and /t,d/ word-internally.

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[2] This notwithstanding the impact of exemplar theory (cf., e.g., Johnson 2007, Foulkes 2010) on phonology and sociophonetics.

2. (t,d)

(t,d) [3] is a variable rule which deletes the second consonant in word-final clusters ending with a coronal stop, as in band pronounced as [band]/[ban] or walked as [wɔːk˺t]/[wɔːk], and is said to apply to all varieties of English (Guy forthcoming). The persistently high level of interest in (t,d) since it was first examined in, for example, Labov et al (1968), Wolfram (1969) and Fasold (1972) stems from the fact that this phonetic/phonological variable occurs in morphologically complex contexts as well as morphologically simple ones and therefore provides a potentially interesting locus for exploration of the interaction between variationist and (morpho)phonological theory. It is now over three decades since Guy (1977) took 'a new look at –t, -d deletion', incorporating interactions between coronal stop deletion and morphological structure using the model of variable rules developed by Cedergren and Sankoff (1974), and it is twenty years since Guy (1991) outlined his refined account of the variable using the recently developed framework of Lexical Phonology (Mohanan 1986). The first major study of (t,d) in British English did not appear until Tagliamonte and Temple (2005, henceforth T&T) tested the model on the York English Corpus (Tagliamonte 1998). T&T's results were not wholly consistent with the predictions of Guy's (1991) model, and it is this which has prompted the critical reevaluation of the variable in present paper.

T&T examined the three independent linguistic variables[4] found to be most robust in conditioning patterns of (t,d) variation in studies of North American English: the

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[3] It will become clear in the course of this paper why I consider terms such as "-*t,d* deletion" problematic. Although this variable notation also implies acceptance of the fact of consonant deletion it should not be taken as such: it is used purely for the sake of convenience, as is the word "deletion".

[4] T&T also tested extra-linguistic variables.

following phonological segment, the preceding phonological segment and the morphological structure of the word. Their data were taken from sociolinguistic interviews with 38 speakers of British English resident in the city of York. After careful auditory and acoustically assisted transcription by two independent researchers the data were coded and analysed in various configurations using GoldVarb 2.0 (Rand & Sankoff, 1990) to perform multivariate analysis. The overall results are reproduced here as Table 1, where the independent variables are presented in descending order of their contribution to accounting for the patterns of variability in the data (judged by the range of factor weights), with their variants listed in descending order of their tendency to favour deletion of final /t,d/. The total number of tokens is slightly higher than Guy's, 1118 compared to 895 (calculated from Guy 1991:5, Table 1), and their distribution across morphological categories is similar, though somewhat better balanced: Guy's data included 658 monomorphemes, 56 irregular past tense forms and 181 regular past tense forms, compared to T&T's 602, 128 and 388 respectively).

The effects of phonological context were broadly consistent with other studies.The identity of the following segment has been found to have the strongest effect in most if not all studies of (t,d), as it does here, the application of the rule being most likely before obstruents and least likely before vowels or pauses. The hierarchy of factor weights was consistent with previous studies, except for the rankings of /r/ and /l/, which lent further support to Labov's (1997) argument that the patterning of following effects cannot be explained in terms of resyllabification, as proposed in Guy (1991). Preceding phonological segment has been considered to exert a relatively weak effect (e.g. by Labov, 1989) but one for which it is possible to draw broadly consistent language-wide generalisations. Thus Labov identifies /s/ >

	CONTEMPORARY BRITISH ENGLISH		
Corrected mean:		.18	
Total N:		1118	
	FACTOR WEIGHT	PERCENT	N
FOLLOWING PHONOLOGICAL SEGMENT			
Obstruent	.84	55	325
Glide	.69	38	106
/r/	.60	28	29
/l/	.50	25	24
Vowel	.29	8	507
Pause	.20	6	127
Range	65		
PRECEDING PHONOLOGICAL SEGMENT			
/s/	.68	42	303
Other sibilant	.58	31	64
Nasal	.50	21	329
/l/	.40	21	126
Stop	.40	16	169
Other fricative	.27	12	127
Range	41		
MORPHOLOGICAL CLASS			
Monomorpheme, e.g. mist	[.53]	30	602
Irregular past, e.g. kept	[.50]	21	128
Regular past, e.g. missed	[.45]	19	388

Table 1. Results of variable rule analysis of the contribution of factors having a potential effect on the probability of *–t,d* deletion. After T&T (293, Table 4). Factor groups not selected as significant are shown in square brackets.

stops > nasals > other fricatives > liquids as a generally consistent cross-dialectal pattern (1989:90). This is not precisely the hierarchy found in T&T's results, nor do their results sit comfortably with an account in terms of the Obligatory Contour Principle, as proposed in Guy & Boberg (1997). T&T considered that fact in itself not to be unduly problematic, since it is generally acknowledged that the strength of effect and hierarchy of variants have varied from study to study. However, we shall return to this contextual effect below.

The results for morphological context in Table 1 are altogether more perplexing. Guy (1991) elaborated an explanation for the frequently observed effect of the morphological makeup of any given word containing a final $CC^{[+cor]}$ cluster within the framework of Lexical Phonology. His hypothesis is that (t,d) applies iteratively at each lexical stratum (i.e. to stems and then to Level I derivations and again at Level II) and his analysis predicts that deletion will occur most frequently in monomorphemic forms such as round and least frequently in regular past tense forms ending in orthographic –ed, such as trashed. Irregular, so-called semi-weak verbal forms, for example kept, with a past-tense suffix but also a vowel alternation in the stem, will pattern intermediately between the other two categories[5]. Many subsequent studies have provided support for this analysis, which has become generally accepted as correct (e.g. Bayley, 1995; Santa-Ana, 1992). However, as Table 1 shows, this was not the case for T&T: although the trend was in the expected direction, morphological class was not selected as significant in their analysis[6]. Moreover, T&T found that other predictions of the Lexical Phonology-based account were not borne out in their data, for example, whereas the hierarchy of factor weights for following phonological segment was consistent across morphological classes, as predicted, the range of those factor weights was not (T&T:294-5, Tables 5a, 5b), which runs counter to expectations. In addition, the direction of the morphological effect did not show the expected consistency across individual speakers even when the category with the smallest number of tokens (semi-weak forms) was disregarded, that is, even

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[5] Although there are possible explanations for why they might pattern with one of the other classes (e.g. Guy & Boyd 1990), they should not show more deletion than monomorphemes or less than regular past tense forms.

[6] Stepping-down Run #8 (all FGs included): Log likelihood -471.150. Stepping-down Run #11 (morphological category excluded): LL -472.186, signif. 0.366.

monomorphemes and regular past tense forms failed to pattern as expected for all speakers (T&T 298, Table 7)[7].

A concomitant prediction of Guy's model is that there will be an exponential relationship between the deletion rales for the three categories.. His Table 2 (1991:10) presents the observed (surface) rates of retention for the three categories and estimated retention rates (p_r) derived from each. The rule applies only once to regular past tense forms, therefore p_r is equivalent to the observed rate of retention (84.0%, 0.840). Since the rule applies twice to irregular forms and three times to monomorphemes, p_r is equivalent, respectively, to the square root and cube root of the surface rate, that is 0.813 and 0.852. If the exponential hypothesis is correct, p_r should be roughly the same in each case; as Guy points out, the p_r figures for regular past tense forms and monomorphemes are close enough to be taken as confirming the hypothesis (with a difference of 0.012). The irregular forms, with a p_r of 0.813, he sees as out of line but he has a plausible explanation for this (1991:9-10). A subsequent analysis of T&T's data yielded p_r values for T&T's data as follows: regular past tense forms, 0.810 (observed 81%); irregular forms, 0.889 (observed 79%); monomorphemes, 0.888 (oberved 70%). Guy provides no metric for evaluating the significance of differences between p_r values, but although the figures for irregular and monomorphemic forms are almost identical, the difference between p_r for these two categories on the one hand and regular past tense forms on the other is at least 0.078, far greater than the difference of 0.027 between his semi-weak and regular forms, which, as just noted, he regards as problematic. Estimated p_r would

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[7] 12/39 speakers deleted more in regular past tense forms than in monomorphemes.

seem, therefore, to be consistent with T&T's conclusions that the data from York do not support the case for an exponential, Lexical Phonology-driven effect.

These figures add further weight to T&T's conclusion that although their study clearly confirmed that the second consonant in word-final $CC^{[+cor]}$ clusters behaves variably, none of the major theoretical explanations of the variability (resyllabification, the OCP, Lexical Phonology) held for their data, despite their having had made every effort to replicate the methodology of previous studies. Their suggestion was that the most fruitful way to move towards a more successful explanation would be to start from a "bottom-up" investigation of the combinatorial phonetic properties of these word-final clusters, given that there has long been plenty of evidence to show that speakers are capable of manipulating fine phonetic detail (e.g., Docherty, 1992; Docherty et al., 1997; Temple, 2000; Carter, 2003). The present paper is intended as a preliminary to such a bottom-up analysis. Many of the issues highlighted here arose initially as methodological difficulties encountered by T&T about which there appeared to be little or no discussion in the available literature but, as we shall see, they have both methodological and theoretical implications, calling into question not merely whether one or other theoretical phonological account of (t,d) is correct, but also the assumptions underpinning the apparently straightforward application of the variable rule construct to coronal stop deletion (and, by implication, final consonant cluster reduction more generally). In the following two section, we discuss an illustrative selection of phenomena posing problems for the identification of where deletion has occurred and for determining how (t,d) might interact with other phonetic/phonological processes affecting the phonological constraints. These phenomena do not merely pose methodological problems, however, they also raise the question of whether (t,d) might not simply be one manifestation of more general processes applying at word boundaries in running speech in English. This leads to a reconsideration in Section 5 of the motivation for treating (t,d) as a variable phonological rule, which in turn leads the discussion back to the possible conditioning effect of morphological category. Section 6 brings phonological and morphological constraints together in considering what might account for the consistent tendency for more deletion in monomorphemes than verbal forms, despite T&T's failure to find statistical support for a Lexical-Phonological effect. The distributional evidence suggests that preceding phonological context in particular is not wholly independent from morphological category and a brief subsequent quantitative analysis of tokens affected by the issues covered in the earlier qualititative analysis adds further grist to this mill. As will become obvious, questions within and across each section of the discussion overlap and interact with each other, creating a complex web which appears to indicate the need for some radical rethinking about variationist approaches to data such as these.

3. Problems with the interpretation of naturalistic data

On the face of it, (t,d) is a relatively straightforward variable to model, involving as it does a categorical alternation between the absence and a surface phonetic realisation of an underlying word-final coronal stop. It is generally acknowledged that a coronal stop following a token constitutes a 'neutralizing environment' (Guy, 1980:4) and tokens in such contexts are excluded from analyses on the grounds that it is not possible to tell whether a stop produced in that context is just a reflex of the following stop or a reflex of both that and the word-final stop. However, the phonetic analysis and coding of the data for T&T showed that this difficulty arose in far more cases than merely the tokens which are conventionally excluded on the grounds of neutralisation. T&T are not the first to be aware of such problems. Wolfram raised the following question in 1993: 'Is it simply enough to note whether the cluster is reduced or not, or must one note finer phonetic points of detail in terms of the cluster? Although some analysts have extracted data by simply counting the consonant cluster as overt or not, I think this is an unwise move, since it presumes that all the relevant linguistic categories potentially affecting the incidence of the variable have been determined' (1993:211). However, it is difficult to find much evidence in the literature that his caution has been heeded. This section will first review what constitutes neutralisation and then examine some further phenomena which can make it difficult to determine whether deletion has or has not applied. The working assumption is that if the LP account is correct any observed phonetic reflex of underlying /t,d/ must mean that the deletion rule has not applied, and any ambiguities in the phonetics must raise a question mark over whether it has applied or not.

3.1 Neutralisation

As already mentioned, the so-called 'neutralising' environment is a context where problems in identifying variants have long been acknowledged: '... in word-final consonant clusters it is necessary to exclude clusters which are immediately followed by a homorganic stop (e.g. test day) from the tabulation since it is sometimes impossible to determine whether the final consonant of the cluster is present or absent' (Wolfram, 1969:48). The exclusion of 'neutralisation' contexts seems to have been normal practice since Wolfram's study, although half the studies cited in T&T give no information about their treatment of clusters in these contexts and there appears to be no in-depth discussion of exactly which contexts should be excluded for this reason. Only one of the studies T&T consulted (Bailey, 1995) also excludes tokens with following interdental fricatives, on the grounds that they are frequently realised as stops by Bailey's Tejano subjects. However, there are other following consonants which could arguably also have this kind of neutralising effect on the variation, but which, to our knowledge, are never mentioned. The most notable is [n], which is also articulated with apical/laminal occlusion at the teeth/alveolar ridge. It might be argued that the presence of nasality would always differentiate the following nasal from the oral coronal stop, and stops, particularly voiceless ones, are often clearly audible even if there is no release before the following nasal. However, nasality as a phonetic property is notoriously non-segmental, that is it is rarely strictly co-temporal with all the other properties of the segment to which it 'belongs'. In (1), for example, the [s] is followed by a brief, nasalised puff of aspiration and a partially devoiced nasal consonant.

(1) *they try their best not* [bɛsʰ̃n̥ɒʔ] *to stay on*[8]

As with /t#d/ and other accepted 'neutralisation' sequences, release of the word-final plosive would in this token not be expected in normal casual, unscripted speech. The nasality is clearly audible from the end of the [s], but it is very difficult to determine whether [ʰ̃] is actually a reflex of an underlying /t/ with nasal assimilation or whether the /t/ has been deleted and the nasal, which does not sound unduly long, is merely partially devoiced. Such decisions cannot be made on an ad hoc basis: decisions of principle need to be taken as to what is to be deemed a sufficient cue to the surface realisation of /t/ or /d/. Discussions of these principles tend in the literature

[8] All numbered examples are taken from T&T's data. In each case the word with (t,d) is underlined in the orthographic transcription and the phonetic transcription is of that word and the following word only. It is not practicable to provide spectrographic illustrations for all examples, so we rely on detailed transcription and description for most.

to be limited to consideration of whether segmental variants such as flaps or glottal stops count as deletion, whereas (1) illustrates a context where the question is what subsegmental properties are sufficient to constitue absence of deletion, in this case whether the voicelessness is ascribable to the /t/ or to the juxtaposition of /s/ and /n/ alone.

In the above cases the problem is determining whether a surface reflex of /t,d/ is present, but a case can be made for treating other following consonants sharing alveolar or dental articulation with /t,d/ as neutralisation contexts on the grounds that in some sequences it is not at all clear that [t] or [d] on the one hand and zero on the other are both likely pronunciations. For example, in /st#s/ sequences in certain syntactic / discourse contexts (e.g. ‘at the last second’), where one might ask whether [sts] is ever a normal pronunciation in natural, rapid speech. Indeed, none of the sixteen tokens of /st#s/ in this data set was pronounced with any surface reflex of /t/. Such problems are, however, not limited to potential ‘neutralisation’ contexts and we now turn to examine some areas which, I would argue, also need principled decisions to be taken about how to interpret the data and which in some cases are impossible to interpret definitively with only auditory and acoustic information.

3.2 Masking Effects

The interpretational problems T&T encountered with the raw data are grouped here somewhat arbitrarily; other groupings and other labels are possible, and the problems illustrated for each group overlap, sometimes to a considerable degree. They all concern phenomena which are instantly recognisable as normal to phoneticians familiar with connected speech processes (CSPs; see, e.g. Farnetani, 1999) and which have been much studied since the early invention of such articulatory techniques as static palatography, since supplanted by electropalatography (EPG), and more recent techniques such as electromagnetic articulography (EMA) or ultrasound tongue imaging (UTI). General comments regarding CSPs here should be taken as referring to varieties of British English; no detailed knowledge of the phonetics of other varieties studied with reference to (t,d) is claimed. The term 'masking' is used here to denote the possibility of an articulatory gesture, possibly an incomplete one, which is physiologically and/or acoustically concealed by the articulation of surrounding consonants[9].

Where there is a following vowel, the duration of the stop closure, the audible release and the visible formant transitions into the vowel make a surface reflex of the (t,d) token easy to identify. (2) and (3) show examples of such non-masked tokens:

(2) *er Simon and I kept in touch* [kʰɛp˺tʰɪntʊtʃ]

(3) *if if a project or* [pɹ̥əʊdʒɛʔtʰɔˑ] *contract comes up*

FIGURE 1

Figure 1. Spectrographic representation of "project or" (3); male speaker.

Figure 1 is a spectrogram of part of (3) showing the preceding /k/ realised as a glottal, a clear closure period and a release with formant transitions consistent with an alveolar plosive reflex of the word-final /t/ of project.

9 For the sake of conciseness, a broad definition of masking is adopted here whereby gestures need not be anterior to the coronal gesture, since the acoustic consequences of the latter can also be masked by an overlapping velar closure, which would prevent the build-up of intra-oral pressure necessary to produce a coronal release burst, particularly with /d/.

In the absence of a release, by contrast, whether or not deletion of word-final /t,d/ has occurred is much less certain, as is the case with (4), illustrated in Figure 2:

(4) *having this lego kept me* [kʰɛ̰p̚miʲ] *occupied for years.*

FIGURE 2

Figure 2. Spectrographic representation of “kept me occupied” (4); male speaker.

As Figure 2 shows, there is glottalisation of the vowel of kept and possibly glottal reinforcement of the [p], but auditory analysis reveals that there is also unambiguous sustained bilabial closure. The following [m] is clearly visible. There is no evidence in the spectrogram or auditorily of a [t] between the [p] and the [m], but it is not possible to state categorically whether there is or is not an apical gesture present. It is quite possible that an apical closure gesture occured, but unless the preceding bilabial closure was released before the [t] gesture, and the following bilabial closure happened after it, it would not be perceived auditorily[10]. This unreleased /p/-to-homorganic /m/ sequence is, of course, exactly what one would expect from a fluent native speaker of English (e.g. Nolan, 1992). Even assuming the absence of a lingual gesture, the presence of glottalisation might be interpreted as a reflex of /t/ in a glottal stop, but this interpretation is no more straightforward: the presence of a masked glottal stop is no easier to identify, and the creaky voicing on the preceding vowel and in the diphthong of occupied, clearly apparent in Figure 2, means that this could just be a function of the speaker’s register.

[10] The relatively short duration of the closure in *kept* compared to the /p/ of *occupied* is ascribable to a rapid deceleration of speech rate and cannot necessarily be taken as an indication of /t/ deletion.

Many tokens showed this kind of effect in T&T's data. In (4) the place of articulation of the preceding and following consonant is the same, but (5) and (6) demonstrate that this is not necessary for masking to occur:

(5) *well it was all* <u>*pressed*</u> *bits of* [pɹ̥ɛsbɪʔ͡tsə] *meat you know*

(6) *but there was all* <u>*old*</u> *carpets* [ɔ̰lkʰa̠pʰɪʔs] *and pictures.*

In each case there is a preceding apical gesture towards the alveolar ridge. Since word-final stops are not obligatorily accompanied by audible release (and arguably not normally so in this type of context), the absence of an audible or visible release burst cannot be taken as unambiguous evidence for deletion of /t,d/: in (5) the blade and tip of the tongue could have raised from their fricative position to form a closure during the articulation of the 'following' [b], just as the side(s) of the tongue could have raised to complete a post-lateral closure in (6). In both cases, any coronal release would be auditorily masked by the closure of the following stop. It is, of course, equally possible that the tongue tip/blade was never raised further than for a fricative in (5) and was released as the dorsum (and sides) raised for [k] closure in (6), but it is impossible to tell either way without direct articulatory data.

Masking is particularly problematic where there is glottalisation of the preceding consonant and with combinations of preceding nasals and following plosives or nasals. (7) is taken from the same clause as (3), focusing on the second (t,d) token; the relevant extract is shown in Figure 3:

(7) *if if a project or* <u>*contract*</u> *comes* [kɒntɹ̥aʔ˙kʊmz] *up.*

FIGURE 3

Figure 3. Spectrographic representation of 'contract comes' (7); male speaker.

Again, the preceding and following segments are unproblematic: there is a clear closure into a glottal reflex of the preceding /k/ of contract and a clear velar release of the initial plosive of comes. Again it is not possible to state categorically that there is not a [t] gesture present, but if this were the case the glottal gesture would have to be released before the release of a [t] and crucially before the velar closure for the following /k/, in order for the presence of the /t/ to be perceived independently or to show up on the spectrogram. Alternatively, given that a glottal stop is a common reflex of /t/, this could be construed as a further neutralising context since the presence of a preceding glottal stop makes it impossible to detect whether the glottal reflex is present or not or to decide whether the glottal is a reflex of /k/ or /t/ or both - see §3.4 below.

The parallel problem with preceding nasals is illustrated in (8) to (10):

(8) *you know we were educated, trained people* [tɹ̥eˑnpiˑpl̩] / [tɹ̥eˑnd̚piˑpl̩]

(9) *they've found me asleep* [faʊnmiʲəslɪˑp] *in their bedroom*

(10) *they were over a thousand quid* [θaᵘzn̩kwɪd] *each*

Occasionally, such cases could be disambiguated from spectrographic evidence, for example a sharp cessation and resumption of voicing with word-final /t/ followed by a voiced stop[11], but unsurprisingly, the majority are more like (8), represented

[11] 9 preconsonantal /d/ tokens with preceding /n/ and following voiceless consonants were devoiced and so also identifiable in this way (total number of /ndC/ = 72). The picture for /t/ is complicated by

spectrographically in Figure 4. The energy showing faintly between the [n] and the [p] release in Figure 4 is from the interviewer speaking over the informant; the informant's closure period between the bold vertical lines on the x-axis is unambiguously voiceless. Prior to that it is possible to see the nasal energy falling off in frequency, but there is no stretch of non-nasalised voicing consistent with a fully voiced [d]. The lack of voicing could be explained by the word-final assimilatory devoicing characteristic of many Yorkshire speakers, but in the absence of a release this potential explanation is of no help in determining whether or not the word-final stop is present.

FIGURE 4

Figure 4. Spectrographic representation of "trained people" (8); female speaker.

Tokens with following nasals or plosives rarely have released [t,d], and those which do have audible release usually involve hesitation or a prosodic pattern signalling a pragmatic or discourse effect. This is the case in (11) and Figure 5, where the speaker is introducing the computer game Minesweeper as the source of his friend's problems with distraction at work and produces a micro pause after found followed by a lengthened diphthong in the first syllable of Minesweeper:

(11) *and he found Minesweeper* [faʊnd̥ maːɪnswiːpʰə], *have you played Minesweeper?*

FIGURE 5

Figure 5. Spectrographic representation of "found mines[weeper]" (11); male speaker.

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the fact that the majority of preconsonantal /nt/ tokens were glottalised (24/31), the proportion rising to 14/16 with following stops/nasals. We return to this distributional imbalance below.

Examples (8) (Fig. 4) and (11) (Fig. 5) were produced by different speakers and the durations are different, but the spectral pattern in found (11) is almost identical, mutatis mutandis, to that in trained (8): in each case there is clear formant structure throughout the voiced portion of the closure for [n(d)] and no voicing bar extending beyond the end of the formants, as there would be in a canonical voiced [d]. The plosive release in Figure 5 is completely voiceless, though not aspirated. This is again quite normal in English and it is difficult to see on what grounds one could possibly state definitively whether or not the stop in (8) (Fig. 4) has been deleted. In that case, even techniques like palatography would not disambiguate the token. It is thus hard to see the justification for extrapolating a phonological rule of deletion from these and the other examples in this section, and even if deletion could be demonstrated, it is hard to see how to justify the claim that it is governed by the same rule that deletes, say, the final /t/ of 'I've never seen the film Gorillas in the Mist [mɪs].'[12] The latter would be marked for speakers of York English and one would expect it to behave quite differently from the examples which are governed by their normal CSPs, yet the same variable rule is purported to apply to all these cases.

3.3 Assimilation

The problem of masking is compounded in cases of assimilation across the (t,d) token. Again, this is particularly a problem with nasals, which frequently assimilate to the place of articulation of a consonant following (t,d). When the underlying token is voiceless, it is sometimes possible still to detect a glottalised reflex of it, as in (12):

[12] An invented example is given here, since there is not a single example of a sentence-final coronal stop cluster with deletion in the dataset analysed in T&T.

(12) *she's on a* *<u>different</u>* *plane* [dɪfɹ̥m̩ ˀpl̥ɛ·n].

Reflexes of /d/ are, however, much harder to detect, as in (13), where the speaker is describing an early record player, and (14), which is shown in Figure 6:

(13) *a a a* *<u>sound</u>* *box* [saʊmbɔks] *was only a diaphragm*

(14) *we built, um, Bradford* *<u>combined</u>* *court* [kʰəmbãĩŋkʰɔːʔ] *centre.*

It could be argued that these assimilation cases constitute evidence in support of a lexical rule of word-final coronal stop deletion: the assimilation in (14) would thus be argued only to occur because the /d/ between the nasal of <u>combined</u> and the velar plosive of <u>court</u> has been deleted before the postlexical rule of assimilation across the word boundary applies. However, in (12) assimilation of the /n/ in <u>different</u> to the place of articulation of /p/ in <u>plane</u> occurs across the glottal reflex of the word-final stop, showing that segmental adjacency is not a prerequisite for assimilation. There might well be a masked apical gesture in (13) and (14), but again it is impossible to tell.

FIGURE 6 AROUND HERE

Figure 6. Spectrographic representation of "<u>combined</u> court" (14); male speaker.

<u>3.4 Data interpretation: a brief overview</u>

The survey of problems in this section is intended to be illustrative and is not exhaustive, but even these affect a substantial proportion of the preconsonantal tokens. The number of tokens potentially affected by each phenomenon, together with the number coded as deleted, is given in Table 2, which shows that they amount to 26% (83/325) of all tokens with following obstruents or nasals, that is the group which was found most to favour deletion by T&T. Of these potentially problematic tokens, 83% were coded, rightly or wrongly, as deleted, a much higher proportion than for following obstruents as a whole (55%).

Example	**Sequence**	**Number of tokens**	**Number coded as deleted**
§2.1	/st#s/	16	16
(4)	bilabial-to-bilabial masking	4	3
(5)	/s/-to-bilabial masking	12	10
(7),(20),(22), (23)	glottal-to-C masking/ glottal ambiguity	15	10
(8),(9),(10),(13),(14)	/ndC[stop]/*	31	27
TOTAL		83	69
Total following obstruents/nasals		325	179

*including tokens assimilated to following place of articulation

Table 2. Numbers of tokens in problematic contexts including following obstruents / nasals.

The implications of the difficulties posed by common CSPs for the accurate and consistent identification of whether a variable (t,d) rule has applied will be taken up again in Section 5 below. However, CSPs also pose problems concerning the interaction of any (t,d) rule with other phonological / phonetic processes and we shall first examine these.

4. Issues concerning the place of (t,d) in the phonology of English

Rules in any derivational model of phonology do not apply in isolation, they belong to the phonology as a whole and take their place in the sequence of rules. The practice of assuming that the phonological context for application of (t,d) consists of the underlying preceding and following segment ought to be justified beyond where it occurs in relation to morphological levels of derivation. This is more than just a matter of principle: there is evidence in the surface forms of other processes having applied, so consideration needs to be given to their interaction with (t,d).

4.1 Interaction with other phonological processes

Masking of the variable is not the only problem posed by assimilation for the analysis of (t,d); assimilation also causes difficulties with determining what the phonological context is when the rule applies. Thus in (12) above we might ask whether the preceding context is a syllabic [m̩] or a coda /n/ prior to undergoing assimilation to the following /p/. The most statistically robust effects of phonological context have concerned manner rather than place of articulation and so place assimilation might be deemed not to constitute a serious problem (although arguably this should be revisited in the light of the above discussion). However, other phonological processes interacting with (t,d) do affect manner of articulation, and even the major class membership of the preceding and following context. Again, we shall demonstrate using case studies of individual tokens.

In (15) there is a clear release of the [tʰ] accompanied by a short aspiration burst, so the token is an unambiguous example of non-application of the rule:

(15) *he was a bit wet when it comes to* *<u>contact</u>* *sports* [kʰɒntʰa̰ʔ͡tʰspɔːʔs]

The following context is unproblematically [s]. However, the preceding context is less straightforward: /k/ is realised as a glottal, which raises the question of what exactly the preceding context was when the rule applied, [k] or [ʔ][13]. It might be argued that what matters for the rule is that [ʔ] is a stop, and its place of articulation is not important, but phonetically it is realised as creak on the /a/ vowel (see Figure 7), and thus in a way which is qualitatively very different from [k]. Of the 169 preceding stops in the York data, 71 are phonetically full glottal stops and 5 are glottalised; glottals in total thus represent nearly 7% of the data set and 45% of preceding stops (76/169) [14], so this is far from being a trivial question.

FIGURE 7

Figure 7. Spectrographic representation of "<u>contact</u> sports" (15); male speaker.

A similar problem occurs with vocalised /l/, as in (16):

(16) *So she <u>told</u> me off* [tʰɐʊmiɔf] *for shouting at her*

York English is not known as a strongly /l/-vocalising variety, but there are ten such tokens in the data set and one, (17), where there is no obvious sequential reflex of /l/ at all:

(17) *my friend <u>told</u> me right* [tʰəmɪ̰ɹ̰a̰ɪ̰] *yesterday*

In these and other cases of the absence of a preceding phonetic consonant, the question arises of how long in the derivation the underlying cluster remained a cluster and so subject to the (t,d) rule. Whereas tokens with preceding phonetic laterals have a mean rule application rate of 19% (total N=104), of the ten tokens[15] where the word-

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[13] Since the rule applies iteratively, the answer to this question may actually be different at different stages in the derivation, thus introducing a further complicating element.

[14] All but one are preceding /k/s, so glottals account for 69% of preceding /k/ (75/109). The other token is /p/.

[15] There were in fact 18 tokens in the whole data set, but some were excluded on other grounds from

final consonant is preceded by a phonetic vowel in the surface form, six (60%) have the final consonant deleted. This may simply be due to the small number of tokens, but it is interesting that syllabic phonetic laterals, also few in number, pattern in the same way as the non-syllabics which surface phonetically (25% deletion, N=8).

Questions concerning the ordering of rules also affect the following phonological context. In cases like (18), where the /t/ coarticulates with the following /j/, the same question arises: what is the following context when the rule applies, in this case postlexically?

(18) *like [the baby] kept you up* [kʰɛp̚ t͡ʃʲʊp̚] *24 hours a night*

Following /h/ is particularly problematic in this respect. In (19) the following context is phonetically a vowel, but underlyingly it is consonantal. What, then, is the following context when the rule applies?

(19) *Yeah that that was it we was walking down Micklegate and we grabbed him* [gɹabdɪm]

The rate of deletion in the 62 tokens with following /h/ is actually just 11%, only marginally higher than the 8% deletion rate for following vowels[16].

All these problems are compounded when the processes affecting adjacent consonants also affect (t,d), as illustrated in (20), where glottalisation might be applying to /k/

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the analysis shown in Table 1. The problem would, of course, be more serious in other varieties of British English where /l/-vocalisation is more common.

[16] 39 of the 62 tokens are followed by a phonetic vowel. The rate of deletion with following [h] is the same as the overall rate, suggesting that even without /h/-dropping, the classification of /h/ with other following obstruents and nasals is erroneous.

and/or /t/, and the sequentiality of the application of glottalisation and/or (t,d) is impossible to determine:

(20) ... *I w- <u>worked</u> part-time* [wə̈ʔpɑ̈ʔtaɪm] *in funerals*

We return to this issue in the following section.

<u>4.2 Sequentiality</u>

Examples (4) and (20) above raise a further question, albeit one which is partly bound up with the other issues discussed in this section, that is the possibility that a phonetic reflex of (t,d) might not occur sequentially between its "preceding" and "following" segments. (4) is reproduced here for convenience:

(4) *having this lego <u>kept</u> me* [kʰɛ̰p̚miʲ] *occupied for years.*

The spectrogram of the token in Figure 2 shows the audible glottalisation on the vowel of <u>kept</u> and into the [p] closure. It is well known that the phonetic cues to segmental identity are not restricted to the temporal slot implied by phonemic (or indeed generative) representations. The cueing of coda voicing by the duration of the preceding vowel is a commonplace, for example. So it might be argued that there is a reflex of /t/ present in the <u>kept</u> of (4), although it is not sequentially aligned in the word-final position. Again, this is a topic which merits further experimental exploration, into both perception and production, beyond the scope of the present paper, but again even on the present evidence the problem is raised of how to classify such tokens for variable rule analysis. T&T decided to classify them, not without some misgivings, as having undergone deletion because they were trying to replicate Guy (1991) and so far as they could ascertain, this would have been Guy's practice.

In (4), there is clear oral articulation of the unreleased bilabial [p̚] of *kept* as well as the glottalisation. By contrast, voiceless velar stops immediately followed by another stop in York English (and many British varieties) are frequently realised as glottals without any velar articulation[17]. These tokens pose a different problem for classifying segments in sequence: in (21) the [tʰ] of worked is released so [ʔ] and [tʰ] can be taken as sequential reflexes of /k/ and /t/ respectively:

(21) *and that was where my dad* *worked* *and* [wɜ̰ʔtʰən] *where the Barbican...*

However, this is not possible in (20), (22) and (23), which are all from different speakers:

(20) *I w-* *worked* *part-time* [wə̈ʔpɑ̈ʔtaɪm] *in funerals*

(22) *She* *knocked* *straight* [nɒʔstɹ̥ɛɪ̰] *into us yeah*

(23) *being an infant teacher was helpful in that* *respect* *because* [ɹɪsbɛ̰ʔ·bɪkʊz̥].

The preceding segment in each case is realised as a glottal stop, and it appears that the (t,d) token is absent. A parallel example, (7), was discussed under Masking above, but even if there were no masked alveolar gesture, [ʔ] is also a possible pronunciation of (t,d) in this variety, as evidenced in (24), so an alternative (or concurrent) interpretation of the problem is that it is impossible to disambiguate whether [ʔ] is a reflex of /k/ or /t/ or both.

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[17] Very occasionally, preceding /p/ is also realised as a glottal stop, as in *the whole place* *except* *us* [iʔsɛ̰ʔˈtʰʊs], but this is extremely rare.

(24) *you felt as* [fɛlʔəz] *if you moved you'd fall off*

It would be necessary to do detailed phonetic comparisons of a number of tokens with potential sequences of glottals to establish whether there is, for example, a regular pattern of variation between a lengthened [ʔ] in worked versus a shorter glottal reflex of /k/ in (I) work, which would indicate (although not conclusively) that there was an undeleted /t/ in this token of worked. In their replication study, T&T again opted to code tokens such as (4), (20), (22) and (23) as deleted because that appeared to be the North American practice, but this is a rather problematic strategy.

The questions raised here cannot be dismissed by saying the rule relates to abstract phonological units or categories of sonority, major class features etc: in order to carry out variable rule analysis, the analyst has to code each token for preceding context, and it is crucial to know what that context is. This is particularly important in cases where the preceding context could be a vowel, which means the cluster may not actually be a consonant cluster when the rule applies, and equally so where the following context may be a consonant or a vowel, given that following consonant versus following vowel has been known (unsurprisingly) to have the most robust effect on (t,d) since the very earliest studies. With an iterative rule, such problems are intractable. It is difficult to see how to determine whether the chicken of rule application came before or after the egg of, say, /l/-vocalisation.

5. Implications of phonetic/phonological processes for the analysis of (t,d)

As explained in the introduction to this paper, the investigation began as an exploration of the methodological problems encountered during the analysis of the data for T&T. In §2 we saw how the illustrative examples surveyed represented a quarter of all tokens preceding obstruents/nasals. The cases exemplified in §3 cover many of the same tokens, but this does not apply to the 62 pre-/h/ tokens: if these are set aside on the grounds that they have probably been misclassified with other obstruents, the proportion of problematic preconsonantal cases rises to 32%. Thus for almost one third of the tokens in the set with the highest rate of deletion it is difficult either to be certain that deletion has actually occurred or to know what the phonological context is when the rule applies or, indeed, both. And this is not an exhaustive tally.

However, the data reviewed raise more than simply methodological issues. The phenomena affecting the analysis of (t,d) are mostly common CSPs, in British English at least, and viewed thus, they are precisely where one would expect most tokens to be perceived as having the final consonant deleted. This begs the question, raised in the conclusion of T&T, of why the variable behaviour itself of /t,d/ in word-final clusters may not "most fruitfully be investigated from the starting point of combinatorial phonetics" (299), that is, as a function of CSPs. This in turn raises questions not only about (t,d) as a linguistic variable analysable in terms of Lexical Phonology but also about the nature of variable rules in general and indeed about the relationship more broadly between phonetic output and phonological analysis.

Although variable rules have their roots in transformational generative phonology, their ontological status has been a matter of debate (see, for example, Fasold (1991) or the brief overview in Mendoza-Denton, Hay and Jannedy (2003)): do they represent a convenient statistical tool for measuring variation or are they an albeit imperfect model of speakers' competence[18]? Whatever the general answer to this question, the linguistic characterisation of (t,d) in terms of the generative LP model entails that the rule be a phonological rule proper, at least so far as morphological class and preceding context are concerned, that is, it applies during the derivation of the word (as well as post-lexically). The question thus arises of how this particular rule fits into the phonology as a whole. It is unproblematic for lexical processes strictly associated with the derivation of verbal forms, such as the deletion (or epenthesis) of the suffix vowel of {-ed} and voicing agreement of the final consonant, to occur before the variable deletion rule applies. However, the indeterminacy of the ordering of the rule with respect to processes affecting preceding and following consonantal segments, to which I have drawn attention in §4, clearly does have direct bearing on any phonological analysis. As we have seen, indeterminacy also surrounds whether the rule has even applied in many cases, suggesting that any re-evaluation of (t,d) should go beyond addressing the ordering of rules and instead re-examine the nature of the rule itself, including whether it is in fact a phonological rule at all.

It is instructive when considering the status of (t,d) to revisit the earlier literature on the variable. The earliest studies by linguists such as Fasold (1972), Labov (1972) and Wolfram (1969) focused on African American Vernacular English, and frequent comparisons are drawn with non-AAV English. To some extent, differences between

[18] Notwithstanding the problems outlined in this paper, (t,d) is an interesting example of how the statistical model of a variable rule can differ from the linguistic variable rule being modelled: morphological category is an independent factor group in the statistical analysis whose function is to model the consequences of the iterative application of the linguistic variable rule, which in the LP view has no need of the input of a linguistic variable of morphological category, since the hypothesis is that its statistical behaviour falls out of the structure of the phonological component of the grammar. This mismatch between a putative linguistic variable rule and the statistical modelling of its behaviour is not in itself problematic.

patterns of cluster reduction are a matter of degree rather than qualitative differences, but there are also qualitative differences, such as the high (and sometimes socially stratified) rates of prevocalic deletion found in many varieties of AAVE and some Southern white varieties, and deletion morpheme-finally but word-internally in, e.g., testing > [tɛsɪn]; these patterns are not found in standard North American English[19] speakers or non-Southern vernaculars, neither are marked patterns of social stratification with respect to (t,d). There have been debates around whether the non-standard patterns reflect distinctive processes or different lexical entries: Butters (1989:120) cites an anecdote concerning a college-educated white, female 63-year-old from North Carolina for whom the word wrist was clearly stored as /rɪs/; Green (2002), by contrast, demonstrates that word-internal, prevocalic cluster reduction behaves differently with different following suffixes and must therefore be governed by grammatically conditioned phonological rules. In either case, whether in the underlying representation or the processes, (t,d) must be a function of AAVE phonology; in Labov's words, 'the frequency of … features such as consonant cluster simplification, and their distribution in relation to grammatical boundaries, is radically different in black speech, and we are forced … to infer the existence of different underlying grammatical forms and rules' (1972:9). Where different patterns of cluster reduction (and other word-final 'deletion' phenomena) are governed by such phonetically transparent constraints as a following consonant versus a following vowel, as in standard North American English and York (British) English, the rules governing them are, again in Labov's words, 'low-level' phonetic ones (ibid:21).

[19] The term 'standard [North American] English' is taken for convenience from the literature referred to in this section.

There was thus explicit recognition in the early literature of a qualitative as well as a quantitative difference between AAVE and other varieties.

This distinction appears to become less clear in the 1970s. Guy (1977) explicitly states that the same rule (of more general stop deletion) as studied in Black English by Labov, Wolfram and others occurs in 'virtually every dialect of English' (1). Narrowing his focus to coronal stops, he argues that while the effects of following segments might be explained in low-level phonetic terms, the effect of following pause and, moreover, the cross-dialectal differences in its ranking with respect to other constraints, may not. Further, the purely functional explanation for consistent differences between consonant deletion patterns in monomorphemic and bimorphemic (regular past tense) forms falls down once a third morphological type, the semiweak verbal forms, is observed to pattern systematically in the data. Guy concludes, therefore, that (t,d) is 'a case where phonological variation cannot be accounted for by the sort of "general functional conditions" suggested by Kiparsky [(1972)], but rather probably must be considered "a rule of grammar"' (ibid:9). Thereafter (t,d) has routinely been treated as a phonological rule and, as mentioned in Section 1 above, it has been studied in the light of various phonological phenomena: core syllabification, the Obligatory Contour Principle and, most famously, as an iterative rule of Lexical Phonology. As Optimality Theory has opened new possibilities for the integration of variation into the phonological component of the grammar, (t,d) has attracted renewed interest from phonologists (e.g. Antila, 2003). It is generally taken for granted that the LP account is correct, and (t,d) has been used to support some quite fundamental theoretical claims: it is a key element in Coetzee and Pater's (2011) analysis of the implications of variation for the structure of the phonological component of the grammar and in Bermúdez-Otero's (2010) counter-arguments to their analysis.

The evidence reviewed thus far, including the various hypotheses tested by T&T, invites us to question whether the assumption that (t,d) is a (lexical or other) phonological rule is indeed correct. The burgeoning field of sociophonetics[20] is testament in itself to the fact that phonetic variability which is not part of the core phonology is not necessarily an automatic result of Kiparsky's 'general functional conditions impinging on speech performance' rendering it, 'unnecessary to investigate variation of this type' (Guy 1977:4). It has long been understood that phonetic detail may be controlled in structured ways by speakers, as in the variable implementation of the voicing contrast across languages, or idiosyncratic or sociolinguistically determined voicing patterns within languages (e.g. Docherty, 1992; Temple, 2000), or as shown by the huge and growing literature on variability in vowel pronunciation in English. So there is no a priori reason why (t,d) should not be a variable phonetic phenomenon[21] which behaves in a structured manner. The present paper does not aspire to draw definitive conclusions about the nature and place of (t,d)[22], but the issues addressed above do have a bearing on this debate and associated problematic questions.

The phenomenon of masking might seem to pose purely practical problems, and an argument could be adduced from the point of view of perception that the masking

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[20] Sociophoneticians would, of course, see this as an umbrella term covering a broad range of approaches which share a common commitment to exploring interfaces between phonetic and variationist theory and practice, rather than representing a monolithic school of thought, in the same way as Laboratory Phonology is an umbrella term indicating a commitment to the use of empirical methods in phonology.

[21] This paper takes an agnostic stance regarding where the dividing line may be drawn between postlexical phonological processes and phonetic CSPs. The crucial issue here is that (t,d) is not characterisable as a categorical (rather than gradient) phonological rule.

[22] These questions are addressed in more detail in Temple (forthcoming).

causes the hearer not to hear a reflex of /t,d/ and it is thus reasonable to model its perceived absence as a result of deletion. However, the generally accepted treatment of ‘neutralisation’ in (t,d) by excluding tokens in (following) neutralising contexts, on the grounds that it is impossible to perceive whether the (t,d) token is deleted or not, demonstrates that (t,d) is modelled on the basis of production rather than perception, as is also implicit in the LP account. Since masking and neutralisation introduce the same uncertainty in the first step of the analysis, that is deciding whether a token is realised or not, they should at the very least be treated in the same way: either neutralised tokens should be included in the analysis because they form part of what the hearer hears (and presumably recognises as (t,d) sites), or potentially masked tokens should be excluded because, as with neutralisation, it is impossible for the analyst or the hearer to detect whether deletion has occurred[23]. Given that production and perception must ultimately be linked, this decision might still be construed as merely an, operational one, but it must nevertheless be addressed and it cannot be given proper consideration without also considering the abstract model of the behaviour of (t,d)[24].

Assimilation was presented in §3.3 above as compounding the problem of masking. Could it be the case, on the other hand, that it confirms that deletion has taken place? In this view, deletion would lead to, e.g., an underlying /n/ and /b/ being adjacent in *sound box* (13), making the assimilation of place of articulation unsurprising. However, the problem of undetectable gestures for [t,d] remains, and the evidence of *different plane* (12), pronounced [dɪfɹ̥m̩ ̰ˀpl̥ɛˑn], shows clearly that

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[23] The decision to exclude all these tokens would of course severely curtail the analysable data set, rendering it in fact impracticable.

[24] As one reviewer points out, a child may well misinterpret a phonetically motivated absence of [t,d] in a parent’s speech as a phonological intention to delete /t,d/. This does not, however, obviate the need to demonstrate positively that the rule is phonological for the child.

assimilation can still take place when the intervening /t/ is not deleted, so its usefulness as a diagnostic is rather doubtful. Moreover, assimilation and the other processes affecting preceding and following consonants raise the question, addressed in §4, of how (t,d) relates to other processes affecting its conditioning: does it apply before or after /l/ vocalisation, /h/ deletion or indeed assimilation? Does it perhaps feed any of those processes? So far as T&T could ascertain, the assumption in the literature seems to be that (t,d) takes units in the underlying phonological representation as its input. This assumption has to be justified, however: on what basis can it be argued that (t,d) belongs in the (lexical) phonology whereas those other processes are either phonetic or post-lexical or even lexical but applying after (t,d)?

One model of phonology which does claim to be able to integrate such complex phonetic observations is Articulatory Phonology, and (t,d) and masking more generally feature prominently in Browman and Goldstein's (1990) foundational paper. Figure 8 shows an acoustic waveform and the trajectories followed by pellets on the major articulators tracked by X-ray during the pronunciation of nabbed most spoken within a phrase. The figure illustrates yet more starkly the need for more abstract models than Articulatory Phonology to address the question of whether (t,d) is a rule of production or perception: the acoustic output here would clearly count perceptually as deletion, and yet there is a very clear production gesture of the tongue blade corresponding with an underlying /d/.

FIGURE 8

Figure 8. X-ray pellet trajectories for 'nabbed most' [næbmost] (Browman and Goldstein 1990:21; Figure 14)

Most pertinent to the question of the nature of (t,d) in a model other than Articulatory Phonology are the similarities Browman and Goldstein observe between cases such as Figure 8 and cases of variable assimilation across word boundaries not involving word-final clusters, as illustrated in Figure 9[25]. Here the final alveolar nasal of seven assimilates to the following stop in plus but again an alveolar gesture remains. Wherever one believes that the phenomena described by Articulatory Phonology belong in a linguistic model, it is apparent that very similar phenomena are being observed in these two cases. In the case of seven plus, a non-AP approach would recognise the (variable) assimilation fairly uncontroversially as an albeit regular gradient phonetic Connected Speech Process of English; given the similarities between that and the case of nabbed most, it would seem that the onus is on those wishing to espouse a more abstract phonological model of (t,d) to demonstrate that the two cases are sufficiently qualitatively different to justify the treatment of the latter as the result of a different, categorical phonological rule[26].

FIGURE 9

Figure 9. X-ray pellet trajectories for "seven plus seven" [sɛvm̩#plʌs] (Browman and Goldstein 1990:22, Figure 11b)

The problem is in fact noted, and discussed in some detail, in an unpublished paper by Myers (1996). As he points out, whereas postlexical processes might be gradient, lexical processes are generally held not to be (cf., e.g., Kiparsky, 1985). The evidence for gradience in (t,d) thus poses a problem for a rule which is crucially both lexical and postlexical and is presented in categorical terms in the literature. Kiparsky allows for the possibility of rules being both categorical (lexically and postlexically) and gradient (postlexically), but the problem remains of how to determine empirically

[25] Browman and Goldstein's Figure 11a shows an unassimilated [n̩#p] sequence.

[26] Since Browman & Goldstein there have been many more recent experimental phonetic studies and some acoustically informed variationist studies with a direct or indirect bearing on (t,d), for example, Mitterer & Ernestus (2006), Raymond et al (2006), Schuppler et al (2009). However, there have to my knowledge been no published studies focussing specifically on (t,d). This in itself is telling. Some of the studies and their implications for an alternative analysis of (t,d) are discussed further in Temple (in press).

what is a categorical and what a non-categorical application of (t,d). Myers develops a distributional method of distinguishing between the two based on the duration of the consonantal portion of the acoustic waveform from the offset of the pre-cluster vowel to the onset of the following word (which was always many in his experiment). This is not the forum to debate the advantages and disadvantages of Myers' methodology. Rather, we might ask why it might be deemed necessary to go to the trouble of developing such methods in the face of the strong evidence of gradience and the unknowability (with currently available methods of investigating natural continuous speech) of categoricity versus gradience because of phenomena such as masking.

The answer for Myers, and currently the only available answer to this question, lies in the interaction of (t,d) with morphology: 'One aspect of the dilemma that will arise seems unshakable: Guy's evidence that in certain dialects of American English t-deletion is both lexical and postlexical. Specifically, Guy has shown that t-deletion interacts with morphology in such a way that it must be analyzed as applying both within the lexicon as well as in a domain larger than the word' (ibid:5). Independently, Bermúdez-Otero (2010) also addresses the implications of the partial gradience of (t,d), and he also argues for a two-step derivation because of its morphological sensitivity. But T&T looked for a robust effect of morphological class from several different angles and none was found, even for monomorphemic *vs.* regular past tense forms. Once again, closer inspection of their data, this time in terms of its distribution, raises more questions than it answered for the standard account of (t,d), and it is to this we now turn our attention.

6. (t,d) and morphology: cross-tabulations

In his critique of explicit claims of independence in linguistics, Paolillo (2011) draws attention to the rarely acknowledged assymetry between Type 1 errors (where a null hypothesis (H_0) is falsely rejected) and Type 2 errors (where a null hypothesis falsely fails to be rejected). This is directly related to the dependence or independence of an observed phenomenon *x* and a possible predictor *y*. H_0 represents assumed independence between *x* and *y*, that is a knowable chance distribution of the data from which it is possible to compute the probability of error; it is therefore possible to set probability levels allowing a high degree of confidence that there is no Type 1 error and that the rejection of H_0 means that there is a dependency relation between *x* and *y*. It is much more difficult to demonstrate independence between *x* and *y*: in this case the hypothesis to be tested against (H_1) represents assumed dependence between *x* and *y*; but since this dependence may be of many types and degrees of magnitude, the probability distribution of what is in effect a Type 2 error is not knowable, "hence claims of independence are not empirically testable" (Paolillo 2011: 261). As Paolillo goes on to show, this problem holds not only for testing the relationship between a dependent variable and a predictor but also for ensuring that multiple predictors are independent of each other, a key assumption of multivariate linguistic analysis. Since the only positive evidence in the literature for the claim that (t,d) is a variable phonological rule in non-AAVE / Southern US varieties is a robust, independent effect of morphological class, any evidence of dependence between this and other predictors would further undermine that claim. A series of cross-tabulations of the York data is presented here, which suggest that the predictors are not wholly independent, whether the dataset is taken as a whole or divided by underlying consonant (for reasons explained below), or whether the focus is narrowed to the problematic cases discussed above, in most of which particularly high rates of deletion can be expected.

6.1 Cross-tabulations of preceding context and morphological category

One type of potential dependence arises from the uneven cross-distribution of predictor factors. T&T followed a strict protocol in selecting tokens for analysis (following, e.g., Wolfram, 1993:214), taking for each speaker the first twenty tokens from each morphological category to maximise even distribution across categories, and only the first three tokens of any given lexical item to control the type-token ratio. The morphological categories were nevertheless still somewhat uneven, with particularly low numbers of tokens in the semi-weak category. Since GoldVarb is designed to cope with such uneven data sets this was not considered too problematic in itself. However, it transpires that the distribution of preceding phonological context across the morphological categories is also very uneven. Table 3 shows this distribution for preceding (underlying) segments, ordered according to their factor-weight rankings in Table 1, with those most favouring deletion at the top. Sibilants other than /s/ are grouped together because they have the same (restricted) distribution across morpheme categories, whereas this is not the case with stops or weak fricatives, which are shown individually. Combined cells in the Factor Weight column indicate that the relevant tokens were tested as a single factor for Table 1. Cells with bold outlined borders are those representing a relatively high proportion of the tokens for that particular morphological group. The cells for /s/ and other sibilants are outlined together in the regular past tense column because although the Factor Weight assigned to the two groups was different when the data set was analysed as a whole (Table 1 above), when morpheme categories were tested separately (cf. T&T:294, Table 5a), all the sibilants in the regular past tense forms (the only group to have sibilants other than /s/[27]) were assigned the same weight (0.69) for this category.

Preceding segment	N	Proportion of total data set	Overall rate of –t,d deletion	Factor Weight (Table 1)	Proportion of morpheme categories		
					Monomorphemes	Semi-weak	Regular past
/s/	303	27%	42%	.68	41%	11%	10%
other sibilants	64	6%	31%	.58	-	-	17%
/N/	430	29%	21%	.50	46%	5%	12%
/l/	130	11%	21%	.40	7%	33%	11%
/k/	109	10%	17%	.40	3%	-	23%
/p/	53	5%	15%		0.5%	21%	6%
/b/	4	0.4%	0		-	-	1%
/g/	3	0.3%	0		-	-	<1%
/v/	74	7%	7%	.27	-	-	19%
/f/	53	5%	19%		2%	30%	0.8%

Table 3. Distribution of preceding phonological contexts across morpheme categories in the York data (percentages higher than 2 rounded up to the nearest whole number).

Comparison across categories shows very different distributions of preceding phonological contexts. Almost half the monomorphemes (46%) are preceded by nasals, which have a statistically neutral effect on deletion (Factor Weight 0.5); the vast majority of the remaining 54% of tokens (~80%, i.e. 41% of the total) are preceded by /s/, which highly favours deletion, whereas very few tokens occur in

[27] This is a consequence of the distribution of /s/ versus /z, ʃ, ʒ/ across the vocabulary of English rather than a function of T&T's particular data set.

moderately disfavouring contexts (10.5%) and only 2% have strongly disfavouring preceding /f/. By contrast, the majority of semi-weak tokens are preceded by moderately or highly disfavouring preceding contexts (54% and 31% respectively). Thus, arguably 80% of variable monomorphemic tokens have preceding consonants which favour deletion, whereas well over 80% of semi-weak tokens have preceding consonants which disfavour it. Moreover, although preceding contexts are somewhat more evenly distributed across the regular past tense tokens, more than 60% also have deletion-disfavouring preceding consonants. This is more starkly illustrated in Figure 10, which shows the distribution of the data both as a whole and excluding the apparently 'neutral' preceding nasal context.

FIGURE 10

Figure 10. Distribution of preceding phonological context across morphological categories excluding tokens with preceding nasals.

In York English, then, preceding phonological contexts are very unevenly distributed across the relevant morphological categories, which at the very least raises doubts as to the independence of the predictors. It is perhaps unsurprising, therefore, that the York data appear to follow the common trend for morphological category effect, with monomorphemes (which have a disproportionately high number of highly deletion-favouring preceding contexts) tending to show more deletion than words in the other categories[28]. Again,T&T had already speculated that the morphological trend might in fact be an artefact of a lack of independence between these predictors (p.296).

[28] Part of the raison d'être of Varbrul programmes is, of course, to deal with such associations, so long as they are not too extreme, so the hypothesis that morphological category has an effect on the variability can nevertheless be tested with GoldVarb, as in T&T and here.

Nevertheless, the overall number of tokens in the York data set is relatively small, and the confound could conceivably be a function of this or of the control critera adopted in the selection of tokens. Therefore the distribution of underlying preceding contexts across the morphological classes of (t,d) words was examined for the present paper in a much larger data set taken from the British National Corpus (BNC), in order to ascertain whether the pattern holds more generally. The comparator data are taken from a comprehensive word-frequency list provided by Kilgarrif[29] for the part of the BNC most comparable to the York Corpus, that is the demographically sampled part of the spoken corpus (Crowdy, 1995), where a geographically diverse sample of the British English-speaking population of the United Kingdom was given portable tape-recorders to sample their own speech and that of interlocutors of their choosing over a period of up to a week. The corpus contains a total of 78,726 (t,d) words, almost ten times the number in T&T and Guy's data sets, and the relevant data are presented in Table 4 and Figures 11a and 11b. No information is currently available regarding rates of (t,d) application in these data, nor is it possible to control type-token ratios as T&T did or to exclude 'neutralisation' contexts[30], so there are major differences between the two sets. Nevertheless an examination of this much larger corpus gives an indication of whether the uneven distributions across the York data are reflective of the (British) English lexicon in general or are merely the result of an unbalanced sample.

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[29] The demographically sampled part of the BNC is also described at http://www.natcorp.ox.ac.uk/docs/URG/BNCdes.html#body.1_div.1_div.5_div.1 (consulted 14.i.11). The list of words and their frequencies was downloaded from http://www.kilgarriff.co.uk/bnc-readme.html on January 7th, 2011.

[30] Since the calculations for the present purpose are derived from a frequency list rather than from the BNC recordings or transcripts, speaker and (non-lexical) contextual information is not available. A detailed study of (t,d) is to be carried out in the near future as part of a project examining word-joins in the British National Corpus at Oxford University Phonetics Laboratory (in collaboration with the University of Pennsylvania) funded by the ESRC (RES-062-23-2566). http://www.phon.ox.ac.uk/wordjoins

Preceding segment	N	Proportion of total data set	Proportion of morpheme categories		
			Monomorphemes	Semi-weak	Regular past
/s/	17214	22%	27%	11%	11%
other sibilants	3895	5%	-	-	21%
/N/	35275	45%	57%	12%	22%
/l/	10076	13%	11%	42%	7%
/k/	5742	7%	3%	-	23%
/p/	2413	3%	0.6%	10%	8%
/b/	171	0.22%	-	-	0.92%
/g/	118	0.15%	-	-	0.64%
/v/	1206	1.53%	-	-	7%
/f/	2610	3%	1.4%	25%	0.91%
/θ, ð/	6	0.01%	-	-	0.03
TOTAL N	78726		53541	6611	18574

Table 4. Distribution of preceding phonological contexts across morpheme categories in BNC data (percentages higher than 2 rounded up to the nearest whole number).

FIGURE 11

Figure 11. Distribution of preceding phonological context across morphological categories in BNC data, excluding tokens with preceding nasals.

As Table 4 and Figure 11 show, the distribution of preceding contexts across the morphological categories is not precisely mirrored in most cases in the BNC data. However, the parallels between the overall trends in the two datasets are strong: preceding contexts found by T&T strongly to favour deletion account for 27% of all monomorphemic words in the BNC dataset but just 11% of the semiweak forms, and contexts found by T&T to disfavour deletion account for 16% of BNC monomorphemes and 77% of the semi-weak forms; the regular past tense forms are again more evenly distributed, although again with considerably more disfavouring than favouring preceding consonants (47.5% vs. 32%). When the preceding nasals, are set aside, as shown in Figure 11, well over half the remaining monomorphemic words once again have deletion-favouring preceding consonants, whereas well over half of the words in the other two categories have preceding consonants which disfavour deletion, the same trend as in the York data. This is consistent with these trends being a function of the phonological structure of the English lexicon and not a flaw in T&T's data. The restricted set of preceding phonological contexts which can occur in semi-weak forms is acknowledged by some authors but the fact that monomorphemes have an equally uneven set of preceding contexts does not seem to figure in discussions of this variable. Hazen, however, does draw attention to problems of statistical interaction in studies not restricted to coronal clusters because /sp/ and /sk/ only occur in monomorphemes:

> First, the potential for skewing the morphological hierarchy will arise, because the monomorphemic forms will have phonological conditioning that the bimorphemic tokens will not have. Second, the potential forms have /s/ as a preceding sound, which has been found to be the preceding environment that most favors deletion. Conversely, when CCR studies report on the preceding /s/ environment, it will have a higher proportion of monomorphemic forms, which will also skew the results.
>
> Hazen (2011: 114)

The cross-tabulations of the York and the BNC data would suggest that the skewing problems are not limited to the over-representation of preceding /s/ in monomorphemes, but concern the distribution of preceding contexts more generally, even when the study is restricted to coronal cluster reduction.

In order to explore the possible implications of such uneven distributions, further analyses of the York data were carried out. T&T's model included both preceding context and morphological category but failed to select morphological category as significant (*cf.* Table 1 above). For the present paper a GoldVarb analysis was carried out replicating Table 1 but excluding preceding phonological context from the model. This produced the same significant range and hierarchy of effect for following context, but a different result for morphological category: the factor group was selected as significant and the range of factor weights was greater, but the hierarchy was slightly different (monomorphemes (.58) > regular past-tense forms (.42) > semi-weak forms (.39) [range: 19]). This is strongly suggestive of an interaction[31] between the preceding segment and morphological category factor groups. Moreover, excluding the numerically small semi-weak category does not affect the flipping between significance and non-significance: for monomorphemes and regular past tense forms only, when all three factor groups are included morphological category is still not selected as significant (monomorphemes (.56) > regular past-tense forms (.40)[32]), whereas when preceding context is excluded from the model morphological category is again selected as significant, with the same distribution of factor weights. As a control exercise, the same procedure was followed disregarding the following context. This made no difference to the non-selection of morphological category: with or without the semi-weak forms, when only preceding context and morphological category were included in the model, morphological category failed to be selected as significant. Clearly, then, morphological category and preceding context are not fully independent, whereas it appears that any interaction there may be between

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[31] In the sense of Sigley's (2003) second type of interaction effect, that is undesirable associations between factors in different factor groups which lead to unevenly occupied cross-tabulation cells.

[32] Significance of log likelihood improvement with addition of morphological category: 0.424

morphological context and following context are well within the capacity of logistic regression to correct (*cf.*, e.g., Sigley, 2003:229). Furthermore, if morphological class and preceding context were truly independent effects, the ranking of preceding context should be consistent across morphological categories and conversely the ranking of morphological effect should be consistent across preceding contexts. This prediction was tested in T&T (293-296) and found not to be robust.

6.2 Cross-tabulations of preceding context and morphological category: /t/ vs. */d/*

Ultimately, the validity of a claim of independence has to rest, in Paolillo's words, "upon the reasonableness of any arguments that were used to suggest it in the first place" (ibid.: 260). This must of course also apply, mutatis mutandis, to claims of dependence between predictors. Having called the independence of the key predictor, morphological class, into question, at least in relation to the York data, we return in the following section to the phonetic and phonological issues exemplified in Sections 3 and 4 above, to examine whether they differentially affect the different morphological classes, thus putting linguistic substance on the distributional suggestions of non-independence. Since those issues affect tokens with underlying /t/ and /d/ differently (e.g. only /t/ generally surfaces as glottalised), separate multivariate analyses of deletion patterns with underlying final /t/ and /d/ were undertaken to provide a context for such an examination. The results are shown in Table 5, which also shows the results from the combined analysis in Table 1 for the purpose of comparison. A further analysis of the data set as a whole, not shown here, which

	(a) WHOLE DATA SET			(b) UNDERLYING /t/			(c) UNDERLYING /d/		
Corrected mean:		.18			.14			.19	
Total N:		1118			677			415	
	FACTOR WEIGHT	%	N	FACTOR WEIGHT	%	N	FACTOR WEIGHT	%	N
FOLLOWING PHONOLOGICAL SEGMENT									
Obstruent	.84	55	325	.88	59	206	.83	52	110
Glide	.69	38	106	.70	39	67	.70	36	39
/r/	.60	28	29	.64	31	16	.69	30	10
/l/	.50	25	24	.53	28	18	.69	33	3
Vowel	.29	8	507	.25	7	291	.31	11	205
Pause	.20	6	127	.13	3	79	.26	10	48
Range	65			75			57		
PRECEDING PHONOLOGICAL SEGMENT									
/s/	.68	42	303	.73	41	302	-	-	-
Other sibilant	.58	31	64	.65	40	30	.53	24	34
Nasal	.50	21	329	.10	3	129	.66	32	201
/l/	.40	21	126	KO	0	20	.46	25	106
Stop	.40	16	169	.47	16	163	KO	0	7
Other fricative	.27	12	127	.41	19	53	.17	7	74
Range	41			63			49		
MORPHOLOGICAL CLASS									
Monomorpheme	[.53]	30	602	[.54]	29	404	[.57]	32	194
Irregular past	[.50]	21	128	[.51]	22	86	[.41]	28	29
Regular past	[.45]	19	388	[.41]	22	187	[.44]	17	192

Table 5. Results of Variable rule analyses of the contribution of factors selected as significant to the probability of -t,d deletion for (a) all tokens (replicates Table 1), (b) tokens with underlying final /t/ only, (c) tokens with underlying final /d/ only. Factor groups not selected as significant are shown in square brackets. KO = "knockout" (categorical retention); tokens excluded from regression analysis.

included underlying final consonant as a factor group selected that factor group as significant, with underlying /d/ favouring deletion over /t/[33].

Table 5 confirms that the following phonological context is a robust, independent predictor: the range of factor weights varies but is consistently greater than for preceding context or morphological class, and their ranking is consistent across the three analyses. By contrast, the ranking of both preceding context and morphological class (which is never selected as significant) are different in each of the analyses, suggesting that not only are they not independent of each other, neither are they independent of the final consonant in the (t,d) cluster. For /t/ tokens, preceding sibilants favour deletion, as in the whole dataset, but nasals, far from being neutral, strongly disfavour it and laterals are followed by categorical retention. In stark contrast to this, it is preceding nasals which most favour deletion with final /d/, outranking sibilants; stops (of which there are very few) and non-sibilant fricatives show categorical and near-categorical retention respectively, whereas they only weakly favoured it with final /t/. /s/ is, of course, absent because of the phonotactic constraints of English (an extreme example of non-independence of underlying final consonant and preceding consonant). Monomorphemes consistently show the strongest tendency to favour deletion, but the disfavouring effects of semi-weak and regular verbal forms are in the opposite order to the LP prediction (and the tendency in the overall analysis) with final underlying /d/. The control analysis reported in Section 3 above excluding semi-weak verbal forms was also replicated separately for

[33] Input: 0.170. Unsurprisingly, given the results shown in Table 5, although the effect of following context was consistent with all other analyses (range: 66) the ranking for preceding phonological context was different from Table 1: /s/ 0.765; /ʃ/ 0.651; stops 0.566; nasals 0.387; non-sibilant fricatives 0.244; /l/ 0.235 (range: 53). Underlying (t,d) consonant was the third strongest effect: /d/ 0.707; /t/ 0.370 (range; 34). Morphological category also showed a significant effect, but not one consistent with LP predictions: semi-weak 0.568; monomorphemes 0.552; regular past tense forms 0.398 (range 17).

tokens with final /t/ and /d/ (not shown here); this produced exactly the same factor-weight rankings, indicating that the phonological effects are robust, and again morphological class failed to be selected as significant in either analysis.

Preceding consonant	**Factor Weight** (Table 5)	**Morphological category**					
		Monomorphemes		Semi-weak		Regular past	
		N	%	N	%	N	%
/s/	.73	250	61	14	14	38	20
other sibs	.65	0	-	0		30	16
/k/	.47	20	5	0		90	48
/p/	.47	3	0.7	27	27	23	12
/f/	.41	11	3	39	39	3	1.6
/N/	.10	120	29	6	6	3	1.6
/l/	KO	5	1.2	13	13	2	1.1

Table 6a. Distribution of preceding phonological contexts across morpheme categories for underlying /t/ (percentages higher than 2 rounded up). Ordered by ranking of preceding consonants in favouring/disfavouring deletion, as in Table 5. Dotted line separates favouring and disfavouring preceding contexts.

Preceding consonant	**Factor Weight** (Table 5)	**Morphological category**					
		Monomorphemes		Semi-weak		Regular past	
		N	%	N	%	N	%
/N/	.66	156	80	0	-	45	23
other sibs	.53	0	-	0	-	33	17
/l/	.46	38	20	29	100	39	20
/v/	.17	0	-	0	-	74	37
/θ/	.17	0	-	0	-	1	0.5
/b/	KO	0	-	0	-	4	2
/g/	KO	0	-	0	-	3	1.5

Table 6b. Distribution of preceding phonological contexts across morpheme categories for underlying /d/ (percentages higher than 2 rounded up). Ordered by ranking of preceding consonants in favouring/disfavouring deletion, as in Table 5. Dotted line separates deletion-favouring and -disfavouring preceding contexts.

Again, an examination of the distributions of preceding contexts across morphological categories, this time by underlying final consonant as shown in Tables

6a and 6b, brings the distributional discrepancies between categories into yet sharper focus. In particular it is noteworthy that the majority (61%) of monomorphemes with underlying /t/ have deletion-favouring preceding /s/, whereas only 29% have preceding nasals, which in this case strongly disfavour deletion. With underlying /d/, by contrast, where preceding nasals strongly <u>favour</u> deletion, they represent 80% of monomorphemes, with the other 20% having moderately disfavouring preceding /l/. In other words, the disproportionate representation of deletion-favouring preceding consonants in this class is seen to be greater than it appeared above once tokens with /t/ and /d/ are examined separately. The effect is less strong for regular past tense forms, but the converse is nevertheless still true: 64% of tokens have deletion-disfavouring preceding consonants with underlying /t/ and 61% with underlying /d/. The distributions for semiweak forms with /t/ are not so straightforwardly suggestive of such an interaction: only 14% have deletion-favouring preceding /s/ but the category appears marginally to favour deletion. With /d/, however, the 100% of tokens with disfavouring preceding /l/ are consistent with the tendency for this category to favour retention most. Here, then, we have further distributional evidence that preceding phonological context, morphological class and underlying word-final consonant[34] are not wholly independent predictors of (t,d). This is all the more reason to return to the qualitative analyses of the problems outlined in Sections 2 and 3, which consider preceding and following contexts and underlying /t,d/, to see whether linguistic analysis can salvage a robust role for morphological structure in the variable behaviour of (t,d).

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[34] Lack of independence between underlying /t/ *vs* /d/ and other predictors does not pose a statistical problem for previous analyses of (t,d), since this is not a predictor which is routinely included in the statistical models, but it must inform our qualitative analysis and we have already seen that it is to an extent consistent with it.

6.3 Cross-tabulations of combinatorial phonetic effects and morphological category

The analytical issues reviewed in §§3 and 4 above were particularly pertinent to preconsonantal tokens which are less likely to incur an audible release of /t,d/ even if a consonantal gesture is present. We shall therefore restrict the following discussion to tokens with following consonants and glides (a total of 484). These represent roughly, though not exactly, the same proportion of each morphological category: 45% of monomorphemes; 49% of semi-weak forms; 39% of regular verbal forms. This distribution in itself could be construed as further contributing to explaining the tendency for more deletion in monomorphemes than regular forms, and indeed regular forms are the only category with a predominance of prevocalic tokens (53%),

		Morphological category								
		Monomorphemes (N=270)			Semi-weak (N=63)			Regular past (N=151)		
	Sequence	N	Del.	% cat	N	Del.	% cat	N	Del.	% cat
(a)	/CC#h/	27	5	10	10	1	15.9	25	1	16.6
(b)	/st#s/	15	15	5.5	0	-	-	1	1	0.7
	/st#C$^{[-cont]}$/	46	35	17	3	2	4.8	9	8	6
	/C$^{[+str]}$t#C$^{[-cont]}$/	0	-	-	0	-	-	4	4	2.6
	/C$^{[-cont,-nas]}$tC$^{[-cont]}$/	0	-	-	6	5	9.5	3	2	2
	/ftC$^{[+lab]}$/	0	-	-	3	3	4.8	0	-	-
	/Ct#C$^{[-cont]}$/ (C_1→[ʔ])	4	4	1.5	0	-	-	4	3	2.7
	/nt#C/	42	3	13.7	0	-	-	3	0	2
	/lt#C/	3	0	1.1	0	-	-	1	0	0.7
(c)	non-assim /Nd#C$^{[-cont][-nas]}$/	10	9	3.7	0	-	-	0	-	-
	non-assim /Nd#N/	8	6	3	0	-	-	1	0	0.7
	assim /Nd#C/	6	6	2.2	0	-	-	3	3	2.1
	[p_m]	0	-	-	0	-	-	1	1	0.7
	/ld#C$^{[-cont]}$/ (C_1→[l])	10	8	3.7	5	3	7.9	4	3	2.6
	/ld#C$^{[-cont]}$/ (C_1→[V])	-	0	-	2	2	3.1	-	0	-

Table 7. Preconsonantal tokens potentially affected by sequential issues in each morphological category. Bold lines separate (a) tokens with /t,d#h/ from tokens with (b) /t#C/ and (c) /d#C/. Dotted lines separate deletion-favouring from retention-favouring /t/ contexts.

but it is the combinations of contexts and their distribution across morphological categories which are more telling. Table 7 shows the distribution across categories of phonological contexts identified above as likely to favour or disfavour perceived deletion of /t,d/. For each category, the total number of tokens in the context is followed by the number of tokens deleted and the proportion of the category accounted for by tokens in that context. Bracketed numbers in the following text refer to illustrative examples discussed earlier.

As noted in Section 3 above, 62 “pre-consonantal” tokens had following /h/, which showed deletion rates more characteristic of following vowels than consonants, regardless of its phonetic realisation. These were relatively evenly distributed across morphological classes as a whole[35] but they represented a slightly greater proportion of preconsonantal verbal forms (c. 16%) than of monomorphemes (10%), which might have depressed preconsonantal deletion rates for those categories somewhat. This is not the case for most of the other preconsonantal tokens relating to the issues discussed. Because of the differing results for preceding consonant shown in Table 5, other tokens with underlying /t/ and /d/ will be considered separately.

As one would expect, the perceived rates of deletion in the types of phonetic and phonological contexts discussed earlier is higher than overall totals for any given preceding context The /st#s/ sequences suggested as a possible instance of neutralisation in Section 3.1 had apparently categorical deletion, and 15 of the 16 tokens are monomorphemes, representing 5.5% of the total number of pre-consonantal monomorphemic tokens. The single regular past tense token, by contrast, represents just 0.7% for that category. Preceding /s/ was also one of the consonants

[35] Monomorphemes 5% (N=27); semi-weak 8% (N=10); regular 6% (N=5).

potentially involved in coronal-to-stop consonant masking (1, 5); the phonotactic constraints of English mean that it only appears with final /t/. Again, although apparent deletion rates are high across classes, the group as a whole represents a higher proportion of preconsonantal monomorphemes (16.7% vs. 4.8% / 6%). Other preceding sibilants only occurred with regular past tense forms and were few in number preconsonantally, taking the total of sibilant-to-stop tokens across /t/ to 8.6%, still only half as many as for monomorphemes. Cases of potential masking between preceding oral stops and following non-continuants (4) were also restricted to verbal forms, with categorical deletion when preceding and following consonants were homorganic and one token with unambiguously non-deleted /t/ in each category when they were non-homorganic[36]. The one case of a monomorpheme with preceding and following homorganic obstruents (in except for) is, unsurprisingly, also deleted. The other context discussed where masking potentially comes into play is where the preceding consonant is glottalised (7, 20, 22). Only a minority of these tokens turn out to be preconsonantal, four monomorphemes (1.5%) and four regular past tense forms (2.7%).

The remaining preconsonantal /t/ tokens with preceding coronals (/n/ and /l/) in fact have very low rates of deletion, as observed in the preceding section, but it transpires that this has nothing to do with potential masking effects, as originally suggested in §3.2, or indeed their absence: three quarters of the tokens with preceding /n/ (29/40) are realised as glottals, as are three of the four tokens with preceding /l/. The very low deletion rates with these preceding consonants are thus explained by the fact that these are precisely the contexts where glottals are a regular, unambiguous

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[36] In both cases (*they kept coming*, and *I'd have been fucked basically*) the discourse context was marked, in the course of relating a dramatic story, so this may have as much to do with discourse function (as in (11), §2.2) as with homorganicity.

variants of /t/[37]. The vast majority of these (40/44) are monomorphemes (a fact again predictable from the morphophonemics of English, since verbal roots ending in nasals or /l/ are followed by /d/), though as we have seen they represent a relatively small proportion of that category.

All illustrative cases with underlying /d/ concerned deletion-favouring contexts, and inspection of the remainder of the data shows no potential cases analogous to the disfavouring /nt/ and /lt/ just discussed. As already noted, Table 5 shows nasals to be the preceding consonants most favouring deletion. The overall preconsonantal rate of deletion with preceding nasals is 38%, but it is evident from Table 7 that, as expected, the types of context discussed in §2 (8-11, 13-14) have much higher rates (overall 86% = 24/28), whether or not assimilation across the /d/ is present. The one non-deleted regular past tense /Nd#N/ token is the one in example (11) above, where release was argued to be marked for discourse purposes. 24 of these tokens are in monomorphemes, which again represents a higher proportion of the category (8.9%) than the four regular past tense tokens (2.6%). The remaining potential masking coronal consonant discussed in §2 (6), /l/, is the only consonant preceding /d/ in semi-weak verbal forms (11% of preconsonantal tokens in the class), and the latter form the only category with vocalised /l/ preconsonantally (16-17). Preceding /l/ also accounts for 3.7% and 2.6% of preconsonantal monomorphemic and regular past tense tokens respectively. Only one regular verbal token analogous to Browman and Goldstein's

[37] There were only two other preconsonantal tokens where /t/ was unambiguously realised as a glottal, one with preceding /p/ and the other with preceding /ʃ/, both verbal forms. This is not the only study to note the importance of taking glottals in this context into account when interpreting deletion data: *cf* Moore & Podesva's (2009) apparently anomalous finding that following vowels strongly favoured /t/ deletion in tag questions, which they explain as the effect of n_#C being predominantly realised as a glottal, and therefore not deleted, whereas n_#V tokens are rarely glottalised and are thus

nabbed most was identified, the /d/ apparently deleted despite the devoicing of the preceding /b/.

In total, tokens corresponding to the issues highlighted in Sections 3 and 4 above comprise 53% of preconsonantal tokens in T&T's data. Numbers per cell are too small for systematic comparison, but there is no evidence in Table 7 of a consistent tendency for more deletion in monomorphemes in these contexts. What the table does show, however, is that the proportion of preconsonantal monomorphemic tokens in contexts strongly favouring deletion is almost double that of regular past tense tokens (37% *vs*. 20%), although the overall rate of deletion in these contexts is the same (84% *vs*. 83%). So once again, combinatorial phonetics would lead us to expect more deletion in monomorphemes. Semi-weak numbers tokens are intermediate in terms of the proportion affected (27%) but with lower rates of deletion (13/17, 75%).

7. Discussion and conclusions

The starting point of this paper was to explore aspects of the phonetics of (t,d) posing methodological problems, in the light of T&T's failure to find evidence in the York data of a robust effect of morphological category and their suggestion that a bottom-up analysis of the variable might be more fruitful. The major effect of following vowels versus consonants found in all studies of (t,d), is very strong and easily explicable in phonetic terms[38]. At the other end of the scale, the examination of a sample of particularly preconsonantal contexts posing analytical problems in terms of identifying surface reflexes of /t,d/, for example as the result of masking, also

[38] This does not preclude a cross-dialectal effect for following pause, as has been found in various studies, but such a cross-dialectal effect is not sufficient evidence that (t,d) is specifically a phonological rule.

yields a set of contexts where high rates of perceived deletion are explicable on purely phonetic grounds without the need to resort to (t,d)-specific phonological explanations[39].

In the face of such observations and of the evidence for gradience noted by other authors, the case for (t,d) as a phonological rule (or a two-step phonological > phonetic one) rests crucially on the consistency of an independent morphological constraint on the variability. This paper has not sought to demonstrate conclusively that the effect of morphological category on (t,d) is straightforwardly an artefact of preceding context. However, the further investigation of the possible confound commented on by T&T has raised further doubts about the independence of the predictor. Most crudely, as shown above, when preceding phonological context is excluded from the statistical model, the morphological predictor appears to be significant, whereas when preceding context is included, morphology is not selected as significant. Further, cross-tabulations at different levels of granularity show a consistent tendency for deletion-favouring phonological/phonetic contexts to be over-represented in monomorphemic tokens. Only 12.5% of monomorphemes have preceding consonants favouring /t,d/ retention overall, compared to 84% of semiweak and 61% of regular verbs (Table 3; Fig. 10), a trend confirmed in the much larger BNC dataset, which suggests it is a function of general phonotactic patterns of English and the structure of the lexicon. The pattern in the York data is even more stark when tokens with underlying /t/ and /d/ are analysed separately (Table 6) and the effect of preceding nasals (the largest preceding category overall) is shown not to be neutral, but most strongly favouring retention of /t/ and most strongly favouring

[39] Temple (forthcoming) provides a detailed comparison of such cases with other word-final cluster and non-cluster consonants using data taken from the York corpus and from a range of published acoustic, auditory and articulatory analyses of CSPs.

deletion of /d/: 80% of monomorphemes with /d/ have preceding nasals, compared to only 23% of regular past tense and no semi-weak forms; conversely with /t/, although there are more deletion-disfavouring nasals in monomorphemes than other categories, these only amount to 29% of the category, 60% of monomorphemes having preceding /s/, compared to 14% of semi-weak and 20% of regular past tense forms (rising to 36%, still well under half, when other sibilants are included). Narrowing the focus yet further, to particular preconsonantal contexts where the discussions in §§3 and 4 above would lead us to expect particularly high rates of deletion again demonstrates that roughly half as many regular past tense forms as monomorphemes (as a proportion of the category) are in highly deletion-favouring contexts with both /t/ and /d/, the semi-weak tokens patterning differentially (Table 7).

This exploration of the distributional problem raised by T&T's findings and further distributional analyses of their data is not in itself definitive, but it does raise questions about the independence of morphological category (upon which the account of (t,d) as a phonological variable crucially depends), some of which seem to have received little attention in the literature on the variable. If the non-significance of morphological category simply means that York English has a different grammar from other varieties then these observations are of little consequence, but the Lexical Phonology account of (t,d) depends crucially on the derivational structure of the lexicon, and therefore dialect-, and indeed idiolect-specific patterning of the effect of morphological category would have to reflect dialect- and idiolect-specific morphology, and (semi-weak forms aside) it would be rather unexpected to find such a radical difference between varieties in this respect, particularly for adult speakers. The finding therefore cannot be dismissed as merely the result of 'dialect-specific instances' (Smith et al. 2009:70, with reference to T&T)[40]. The difference, if there is one, would have to be that (t,d) is an iterative lexical rule in other varieties and an exclusively post-lexical one in this, a possibility for which a positive case would have to be made.

Nor can T&T's findings be dismissed as one anomalous study: Smith et al.'s results are also inconsistent with the LP account of (t,d); they do find a statistically significant effect for morphological class in their adult speakers, but rates of deletion in the semi-weak forms falls outside the range for regular and monomorphemic forms, being significantly lower than for regular past-tense verbs. It is difficult to see how a plausible account of this finding could be found within LP[41]. Hazen also found a relatively weak morphological effect on (t,d), but his best fitting morphological categorisation was not consistent with the LP model either, since neither monomorphemic nor regular bimorphemic forms behaved as a single group (2011:27). He highlights a further possible respect in which predictors of (t,d) are not fully independent, suggesting that "apparent morphological influences are actually [following] phonological influences that present themselves as morphological trends" (ibid.:1), an observation consistent with both the overall distribution of following consonants and vowels in the present study and (on a much smaller scale) the proportion of following /h/ in each category.

In fact, Guy himself has recently cast some doubt on the role of morphology, on different grounds. Table 8 shows some results from his study with Hay and Walker (2008) on early New Zealand English. No results are given for preceding

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[40] This does not preclude cross-dialectal differences in overall rates of deletion or in preceding or following phonological effects.

[41] Note that Smith et al. make no claim to confirm or refute the LP-based account.

phonological context, and we are not told why it was excluded from the model, but whereas lexical frequency has a highly significant effect, morphology does not. Moreover, Guy, Hay and Walker comment that, 'Interestingly, [lexical frequency] appears to predict much of the morphology effect that has received so much attention in prior studies, due to the differing frequency profiles of the relevant morphological categories… Once frequency is taken into account, a much more modest role for morphology remains' (ibid:1).

	Chi-sq	**df**	**P**
Log local frequency	12.3	1	0.0005
t vs. d	16.56	1	<.0001
following environment	623.48	5	<.0001
most common following environment	23.08	5	0.0003
and (Factor+Higher Order Factors)	86.94	2	<.0001
hesitation (Factor+Higher Order Factors)	59.55	2	<.0001
Speaker	190.75	18	<.0001
morphology	7.62	2	0.0221
went	17.86	1	<.0001
not	19.22	1	<.0001
local speech rate	5.27	1	0.0217
and * hesitation (Factor+Higher Order Factors)	13.42	1	0.0002
TOTAL	1114.88	38	<.0001

Table 8. Wald statistics for model of t/d deletion investigated by Guy, Hay & Walker (2008).

What, then, does this investigation into the implications of T&T's findings lead us to conclude about the nature of (t,d)? The procedural problems posed by the phonetic issues illustrated here are not inconsequential for the analysis of (t,d), but even leaving those aside, it is clear that (t,d) is at least in part a gradient process and it is therefore problematic to characterise it as one binary categorical iterative rule. Bermúdez-Otero, assuming that the morphological effect is real and not artefactual, has argued convincingly that the co-existence of a categorical and a gradient (t,d) rule is perfectly plausible as a result of diachronic 'rule scattering' (2010:1). But this account is not necessary if the morphological conditioning is not in fact real. The lexical frequency effect found by Guy et al may, of course, be compatible with either a phonological or a phonetic/postlexical account of (t,d), or indeed a dual account. However, once the role of morphology is downgraded as largely artefactual of, for example, lexical frequency or major morphological categories are shown not to pattern in a consistent manner, there seems little positive reason to treat it as a (lexical) phonological rule rather than a surface phonetic one and it behoves the advocates of the LP or other phonological analyses to provide further grounds that it should be treated thus. Treating (t,d) as a phonetic Connected Speech Process (or a gradient postlexical rule) is not to relegate it to the level of performance errors and it does not preclude its being variable and structured, but as well as allowing a more holistic approach in the light of what is known of other CSPs in English, viewing it this way obviates the need to justify a more abstract phonological analysis. It does not, of course, mean that issues like masking, the ordering of processes and assimilation disappear, and evidently it also behoves proponents of this view of (t,d) to make a positive case for such an analysis, but that will have to await a further, fuller treatment than is possible in the present paper.

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FIGURES

RETHINKING (t,d)

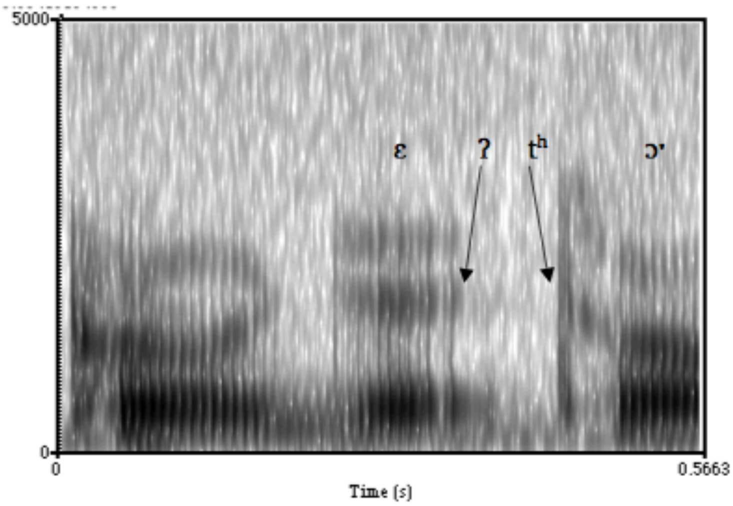

Figure 1. Spectrographic representation of "project or" (15); male speaker.

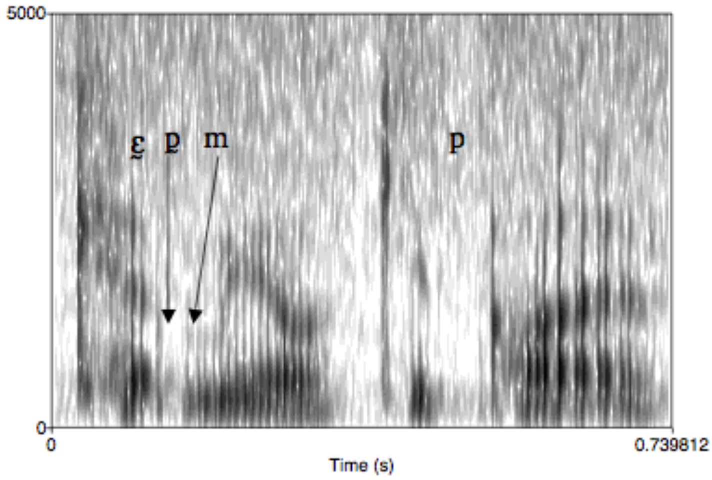

Figure 2. Spectrographic representation of "kept me occupied"

RETHINKING (t,d)

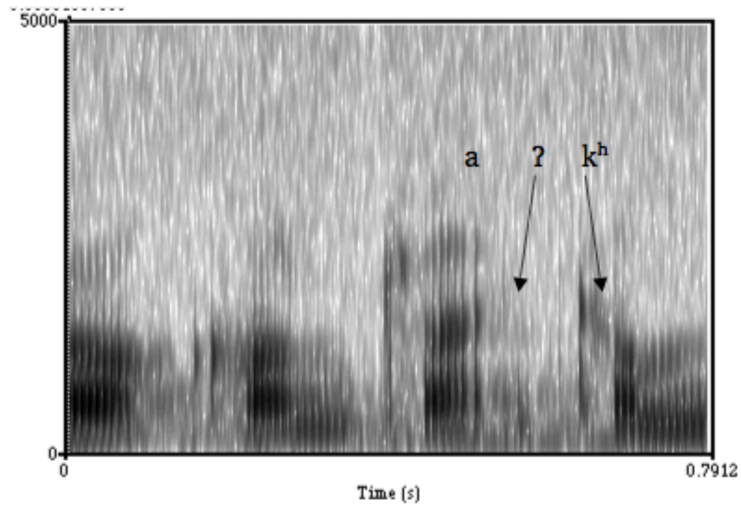

Figure 3. Spectrographic representation of "<u>contract</u> comes" (4); male speaker.

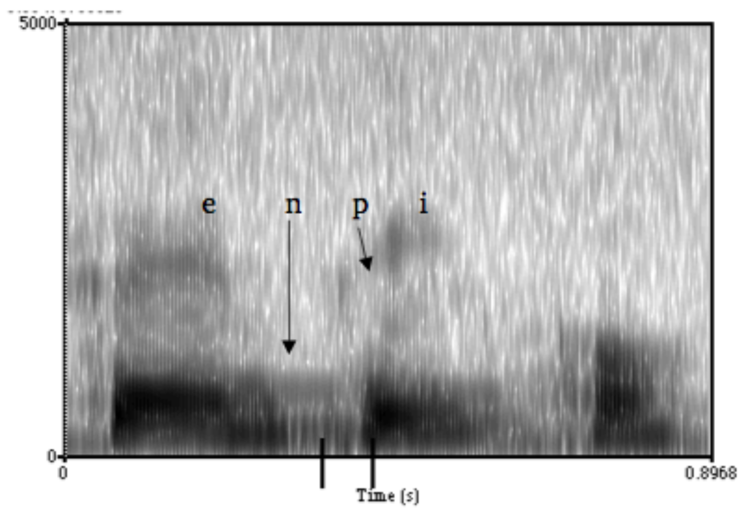

Figure 4. Spectrographic representation of "<u>trained</u> people" (8); female speaker.

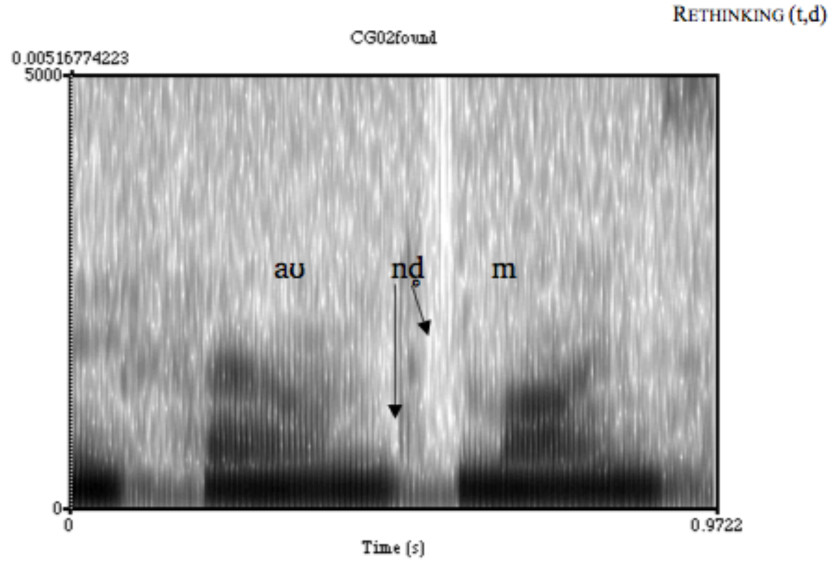

Figure 5. Spectrographic representation of "he found mines(weeper)" (8); male speaker.

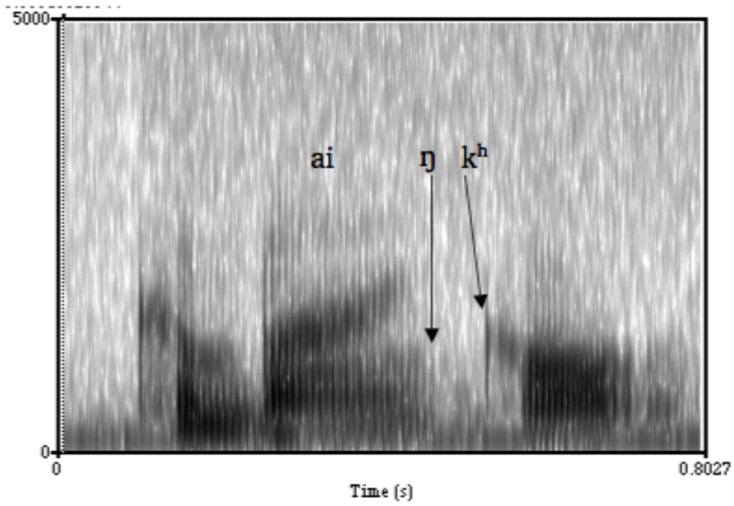

Figure 6. Spectrographic representation of "combined court" (14); male speaker.

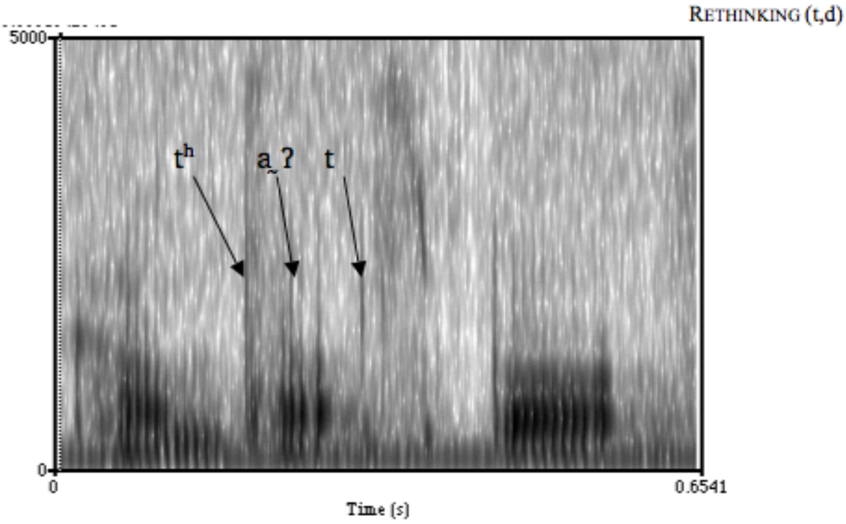

Figure 7. Spectrographic representation of "<u>contact</u> sports" (15)

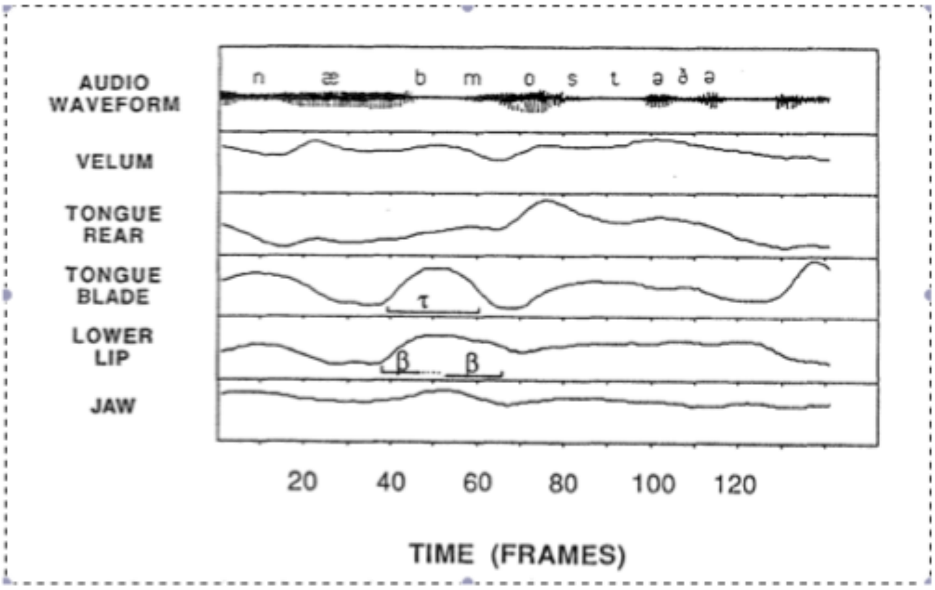

Figure 8. X-ray pellet trajectories for 'nabbed most' [næbmost] (Browman and Goldstein 1990:21)

RETHINKING (t,d)

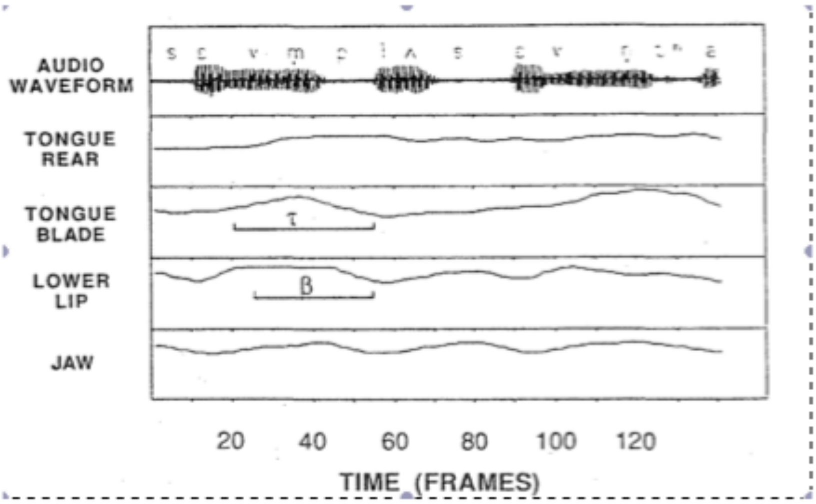

Figure 9. X-ray pellet trajectories for 'seven plus seven' [sɛvm̩#plʌs] (Browman and Goldstein 1990:22)

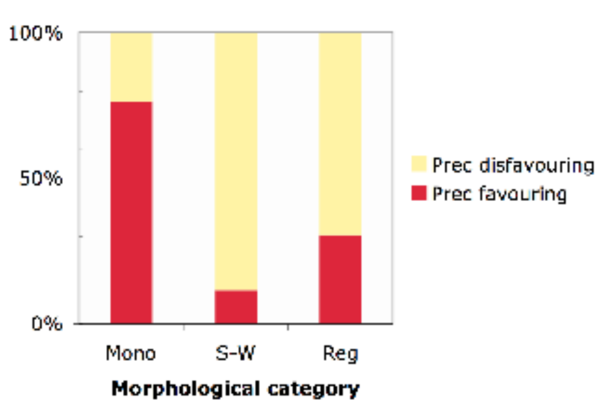

Figure 10. Distribution of preceding phonological context across morphological categories in York data excluding tokens with preceding nasals.

RETHINKING (t,d)

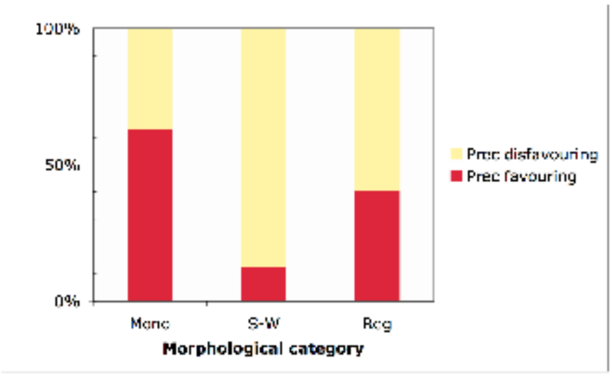

Figure 11. Distribution of preceding phonological context across morphological categories in BNC data excluding tokens with preceding nasals.