

Speech rate plays marginal role in processes of connected speech

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ABSTRACT

The study seeks to establish the frequency of occurrence for processes of connected speech and to examine the role of rate, hypothesizing that high rate fosters processes. Auditory and acoustic analysis was performed on 4.5 hs of speech of 9 speakers of Lancashire from the Phonologie de l'Anglais Contemporain corpus (PAC). As for the first aim, the following ranking emerges: /d/ deletion (34%), /t/ deletion (31%), /h/ deletion (20%), fricativization (9%), yod coalescence (3%) and assimilation of place (2%). This hierarchy of occurrence can be explained with the two factors: lexical frequency and interspeaker variability.

A surprising finding is that rate effects, with exception of /t/ deletion, were not observed for individual processes or across the gradient/categorical division, pointing to a less significant role of tempo than it is assumed. Instead, it is suggested that connected speech processes are phonological, not phonetic.

Keywords: connected speech, consonants, speech rate.

1. INTRODUCTION

Connected speech is subject to massive reduction of sounds [9, 14]. Typically, vowels are studied in the reductionist paradigm; in comparison, processes affecting consonants have received less scholarly attention. In the literature, a selected process in a standard variety is examined, with a strong focus on /t, d/ deletion [6, 13, 15, 4]. It would be highly informative to investigate all processes in a nonstandard dialect such as Lancashire to establish their relative frequency. Currently, one may encounter impressionistic descriptions such as: “in connected speech, /m/ frequently results from final /n/ of the citation form before a following bilabial” ([1] : 311) or “palatal harmony is more in evidence than the other types” ([11]: 92). Thus, the study seeks to reduce the arbitrariness surrounding the question how frequent *frequent* is by establishing the frequency of occurrence for /t, d, h/ deletion, fricativization, assimilation of place and Yod coalescence. The second aim is to correlate processes with speech rate, hypothesizing that (i)

rate fosters reduction [5] (ii) gradient processes in which only a part of segment is reduced (fricativization, assimilation, Yod coalescence) are more rate-sensitive than the categorical ones where a segment is not realized (deletion).

2. METHOD

Acoustic analysis was performed on 4.5 hrs of speech of 9 Lancashire speakers from the PAC corpus [2]. PAC's structure is as follows: a list of words, a read passage, formal and informal interview. The study analyzed both formal and informal interviews, the difference between the two types of interview being only nominal, both were loosely structured and conducted in an informal setting, at informants' homes or workplaces. The formal interview was conducted by a French speaker of English, a stranger to informants whereas the informal interview was carried out by a native speaker of Lancashire who was either a relative or a friend (or a family friend) of informants.

For /t, d/ deletion, a visible stop burst or lack thereof was a cue, lack of noise frication manifested as mid and higher frequencies darkening on a spectrogram and irregular wave on a waveform indicated /h/ deletion. Special care was taken to annotate only those cases where deletion was complete. Fricativization was annotated if the stop clearly manifested an incomplete burst and released itself into preceding and following vowel. Assimilation of place was judged by, e.g. lowering of formants in /n/ towards the bilabial gesture such as in the phrase *in Bolton*. Yod coalescence was annotated if formants exhibited a significant raising toward palatal /j/ on a spectrogram. From the annotation, geminates of the kind *want to* were excluded, so were all the lexicalized cases of Yod coalescence, e.g. *education, gradual*.

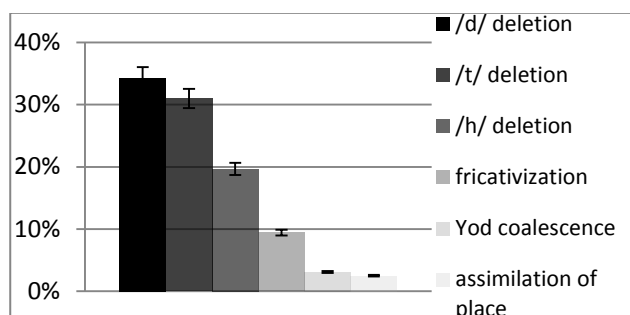
The possibility of correlation between processes and speaking rate was operationalized with multivariate regression. Rate was measured individually for each speaker as syllables per second and then normalized as a ratio of duration of the speakers' speech to the number of syllables in a given recording (the length of recordings varied from 12 to 28 minutes).

3. RESULTS

3.1. Results for frequency of occurrence

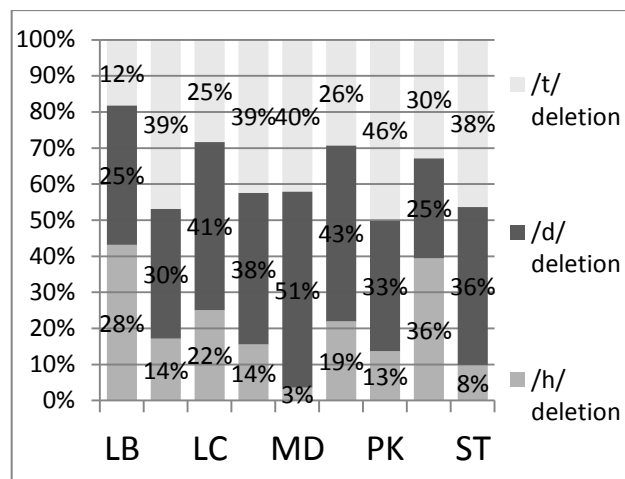
3401 instances of processes of connected speech were found in the PAC corpus of 32. 016 words, the former number was taken as 100 per cent. As for the first aim, the following ranking emerges:

Figure 1: Frequency of occurrence of processes



The processes can be ranked according to the most to the least frequently occurring: /d/ deletion occupies the top of the ranking with 34 per cent, /t/ deletion follows it closely with 31 per cent. /h/ deletion had a 20 per cent frequency of occurrence (both in function and lexical words), whereas fricativization had 9 per cent. At the other end of the ranking, Yod coalescence (3 per cent) and assimilation of place (2 per cent) are placed. Examples from the corpus included: /t/ deletion: *didn't go, different countries, just meaningful*; /d/ deletion: *pounds, grandchildren, sandwich*; /h/ deletion: *at home, I've had, perhaps*; fricativization: *obviously* (/b/ lenited towards /v/), *absolutely* (/b/lenited towards /v/), *working* (/k/ lenited in the direction of /h/); assimilation of place: *seven* (/n/ assimilated into /m/), *in winter* (/n/ assimilated into /m/); Yod coalescence: *was younger, once your, reality hits you*. This ranking is established for all 9 speakers, whereas their individual frequencies are captured below.

Figure 2: Distribution of deletion processes across speakers



As evident from Figure 2, both /t, h/ deletion exhibit a similar amount of variability, ranging between 12-46 /t/ and 3-36 per cent /h/. For /d/ deletion, variation among speakers is slightly lower, i.e. from 25 to 51 per cent.

Figure 3: Distribution of fricativization and assimilation processes across speakers

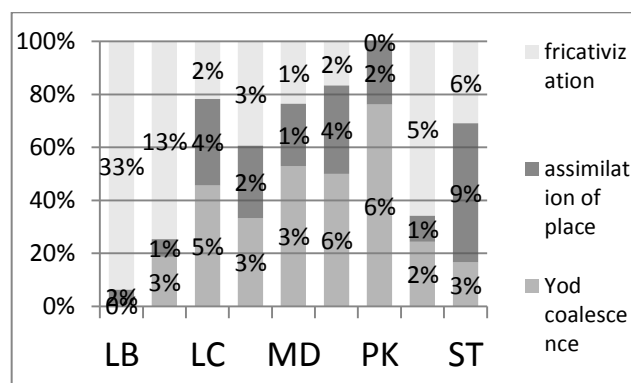


Figure 3 reveals that only fricativization is distributed in similar pattern to figure 2 (from 0 to 33 per cent). Other non-deletion processes demonstrate much lower degree of variability among speakers: assimilation of place from 1 to 9 per cent whereas Yod coalescence from 0 to 6 per cent. In comparison with Figure 2, Figure 3 demonstrates that certain speakers do not use a process at all or use a selected process rather extensively, meanwhile deletion processes are used by all speakers. This outcome dovetails with what [7] have predicted: "Future studies focusing on both categorical and gradient reduction may report larger individual differences" ([7]: 22).

3.2. Results for rate

On the assumption that the higher the rate, the higher the frequency of processes, a Pearson correlation between rate and number of processes per speaker was run: $r = -0.22$ in wake of which, hypothesis (i) that rate triggers processes cannot be upheld. In search of alternative explanation, other extralinguistic variables than rate were factored in, i.e. age and education (gender could not be included as all speakers were female).

Table 1: Multivariate regression of rate, age, and education

Regression statistics					
Multiple R	0,50				
R square	0,25				
Adjusted R square	-				
Standard error	105,55				
Observations	9				

ANOVA					
	df	SS	MS	F	Significance F
Regression	3	191,28	637,5,9	0,57	0,66
Residual	5	557,08	111,42		
Total	8	748,36			

	Coef	Standard error	t Stat	p-value	Lower 95%
Intercept	120,922	651,71	1,8555	0,12	-466,050
rate	-119,451	130,78	-0,913	0,40	-455,64
age	-4,18033	3,9464	-1,059	0,34	-14,32
education	-21,193	22,307	-0,947	0,39	-78,46

The p values point to lack of connection between rate, age and education in occurrence of a process. More importantly, the R square value informs that the 3 factors considered account only for 25 per cent of variation among speakers. Therefore, not only rate but also age and education seem to play an insignificant role in occurrence of processes. Turning to the second hypothesis the study sets out

to validate, it stipulated that categorical processes (deletions) are rate resistant, while gradual processes (assimilation, Yod coalescence and fricativization) display sensitivity to rate.

Table 2: Categorical vs. gradient processes

categorical processes		rate	Gradual processes		rate
LB	13%	3,20	LB	40%	3,20
JM	13%	3,13	JM	15%	3,13
LC	13%	3,59	LC	9%	3,59
MC	12%	2,83	MC	6%	2,83
MD	10%	3,21	MD	3%	3,21
MO	8%	2,86	MO	6%	2,86
PK	9%	3,20	PK	4%	3,20
SC	16%	2,80	SC	8%	2,80
ST	7%	3,56	ST	8%	3,56
		$r = -0,38$			$r = 0,1$

In light of the results from table 2, hypothesis (ii) has to be rejected: the category of a process appears not to be sensitive to rate. A question might be posed which processes of connected speech (if any), taken separately, exhibits sensitivity to rate.

Table 3: Correlation between rate and processes

	rate	/d/ deletion	/t/ deletion	/h/ deletion	fricativization	yod	assimilation
LB	3,20	12%	22%	12%	60%	10%	3%
JM	3,13	11%	23%	11%	17%	12%	7%
LC	3,59	14%	14%	16%	3%	18%	20%
MC	2,83	13%	21%	10%	4%	10%	12%
MD	3,21	13%	16%	2%	1%	8%	5%
MO	2,86	10%	1%	9%	2%	13%	13%
PK	3,20	8%	1%	6%	0%	14%	7%
SC	2,80	11%	1%	32%	8%	9%	5%
ST	3,56	7%	1%	3%	4%	6%	29%
		$r = -0,04$	$r = 0,73$	$r = -0,12$	$r = 0,13$	$r = -0,1$	$r = 0,02$

Table 3 depicts that only /t/ deletion out of six processes of connected speech considered in the study shows any, albeit feeble, effects of speech rate.

4. DISCUSSION

With regard to frequency of occurrence, a direct comparison to any study is not yet viable since in the literature, a process is investigated individually rather than relative to other processes. Only the results reported for assimilation and Yod coalescence are very much in line with [8]'s findings who also established that assimilation of place (including Yod coalescence) does not exceed 5 per cent. Nevertheless, the study does establish the actual frequency of occurrence. Against this background, it is possible to verify statements such as: "there is little or no lenition of the type stop → fricative" ([11]: 89).

Frequency of occurrence cannot be discussed separately from lexical frequency. In the present study, the case of /d/ deletion serves as a prime example: the word *and* alone constituted 80 per cent of all cases in which /d/ was deleted. This is consistent with the results of [12]. A similar phenomenon has been reported by [10] who explained the pattern of /t/ deletion via high frequency of *just*. In the study, it has been observed that high lexical frequency neatly dovetails with the frequency of tokens of a word which underwent a process: *just* was the top most frequently reduced word in the /t/ deletion category, its overall frequency rank in the corpus being 20th. Token *friends* ranked as 143rd (/d/ deletion excluding *and*), *have* as 34th (/h/ deletion), *it* as 7th (fricativization), *in* as 10th (assimilation) and *year* as 107th (Yod coalescence).

In addition, the study takes up speaker-dependent variability which is often disregarded in the literature. Upon a closer inspection of Figures 2 and 3, it becomes evident that much of the frequency patterns can be accounted for by the differences between subjects. Speaker LB alone produced a strikingly high number of fricativization processes, her contribution is 60 per cent to all fricativization processes. Meanwhile, speaker PK did not display any single case of fricativization in her speech. In similar vein, speaker SC was very active in the area of /h/ deletion with 27 per cent of all /h/ deletion processes. At the other end of the spectrum, speaker JM deleted /h/ to an insignificant degree. Speaker ST had a rate of assimilation of 5 per cent, by contrast, speaker LB's rate was nearly zero. The differences between individual speakers were remarkable, leading to the possibility of considering speaker-dependent variability as one of the major factors in patterning of connected speech processes.

Another noteworthy observation is the lack of differences in frequency of processes between formal and informal interview (cf. section 2). Given

that the informal interview was carried out by the speaker of the dialect and the informal by a person with a detectable French accent, it was only logical to expect higher frequency of processes in the informal interview than in the formal one. This, however, was not the case as frequency of processes was 53 per cent in the informal part and 47 in the formal one. These results point to an insignificant difference which seems not to be far from what [4] report for Dutch: "the components with casual conversations (either face to face or by telephone) contain higher percentages of highly reduced pronunciation variants (on average 38%) than the components with speech produced in formal situations (on average 33%)" ([4]: 71).

The study hypothesized that rate has a positive effect on processes of connected speech. As for the first hypothesis, the results offer no support. Analysis of rate, age, and education combined did not tease apart any single factor as triggering occurrence of connected speech processes. In fact, their relative weight remains inconclusive as only one fourth of the variation was explained by rate, age and education (Table 1). In light of the results, the role of rate, age and education in consonantal processes does not seem to be as relevant as it has been previously reported for vowels. Regarding hypothesis (ii), as apparent from Table 2, it cannot be upheld. Gradient processes were not more prone to rate effects than deletions. Finally, the study addresses a question which of the 6 processes considered individually shows effects of rate. Table 3 demonstrates that only /t/ deletion is correlated with speech tempo, the correlation is still relatively feeble ($r=0.72$). This observation agrees well with what [1] notes: "elisions do show some correlation with rate of deliver. In all styles they become more frequent as the rate of utterance increases" ([1]: 310-311). Thus, the study's outcomes cannot positively verify the hypothesis that high speech rate fosters high frequency of occurrence of connected speech processes. Instead, it is suggested that consonantal processes belong to speaker's phonology.

To sum up, the study establishes a frequency of occurrence for consonantal processes in Lancashire and accounts for it with lexical frequency and interspeaker variability. The study also raises some doubts about the role of speech rate in occurrence of a process. A suggested future direction is to run parallel studies on RP as well as other dialects with a view of answering the inevitable question to what extent the distribution of connected speech processes is dialectal.

Acknowledgements

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5. REFERENCES

- [1] Cruttenden, A. 2008. *Gimson' Pronunciation of English*. 7th edition. Hodder Education: London.
- [2] Durand, J., Pukli, M. 2004. How to construct a phonological corpus: PRAAT and the PAC project. *Tribune Internationale des Langues Vivantes (TILV)*, Vol. 36, 36-46.
- [3] Durand, J., Gut, U., Kristoffersen, G. 2014. *The Oxford Handbook of Corpus Phonology*. Oxford: OUP.
- [4] Ernestus, M., Hanique, I., Verboom, E. 2015. The effect of speech situation on the occurrence of reduced word pronunciation variants. *Journal of Phonetics*, 48(2015), 60–75.
- [5] Fosler-Lussier, E., Morgan, N. 1999. Effects of speaking rate and word frequency on pronunciations in conversational speech. *Speech Communication* 29, 137-158.
- [6] Guy, G.R. 1992. Explanation in variable phonology: An exponential model of morphological constraints. *Language Variation and Change* 3, 1–22.
- [7] Hanique, I., Ernestus, M., Boves, L. (In press). Choice and pronunciation of words: Individual differences within a homogeneous group of speakers. *Corpus Linguistics and Linguistic Theory*.
- [8] Huber, D. 2010. The extent of place assimilation across word boundaries in Lancashire English. Presentation at the *15eme Colloque ALOES*, Universite Paris 13, Villletaneuse.
- [9] Johnson, K. 2004. Massive reduction in conversational American English. In Yoneyama, K., Maekawa, K. (eds.) *Spontaneous Speech: Data and Analysis. Proc. of the 1st Session of the 10th International Symposium*. Tokyo, Japan: The National International Institute for Japanese Language, 29-54.
- [10] Labov, W. 1975. The quantitative study of linguistic structure. In K. H. Dahlstedt (ed.), *The Nordic languages and modern linguistics*. Stockholm: Almqvist and Wiksell, 188–234.
- [11] Lodge, K. 1984. *Studies in the phonology of colloquial English*. Croom Helm.
- [12] Neu, H. 1980. Ranking of constraints on /t,d/ deletion in American English: A statistical analysis. In Labov, W. (ed.), *Locating language in time and space*. New York: Academic Press, 37–54.
- [13] Raymond, W. D., Dautricourt, R., Hume, E. 2006. Word-medial /t,d/ deletion in spontaneous speech: Modeling the effects of extra-linguistic, lexical, and phonological factors. *Language Variation and Change*, 18 (1), 55-97.
- [14] Shockey, L. 2003. *Sound patterns of spoken English*. Oxford: Blackwell Publishing.
- [15] Zimmerer, F., Scharinger, M., Reetz, H. 2014. Phonological and Morphological constraints on German /t/-deletion. *Journal of Phonetics*, 45, 64-75.
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