Priming as a motivating factor in sociophonetic variation and change

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ABSTRACT

Understanding how and why pronunciations vary and change has been a dominant theme in variationist sociolinguistics (Labov 1966, 2001). Linguistic variability has also been an area of focus in psychology and cognitive science. Work from these two fields has shown that where variation exists in language, an alternative form, once used, persists in working memory and has a greater chance of reuse (Bock 1986; Bock & Loebell 1990; Branigan et al 2000). While there have been efforts to connect priming research with sociolinguistics at the level of grammar (Poplack 1980; Travis 2007), there has been less work which explicitly considers the potential role of priming as a motivating factor in accent variation and change. This paper explores the role of priming in a socially-conditioned sound change. There are two main findings: (1) phonetic variants with the same voicing tend to cluster together in naturally occurring speech and (2) repetition of phonetic form interacts with widely attested sociolinguistic predictors of variation. I argue that there are benefits to both cognitive science and sociolinguistics from this synergy: incorporating research from cognitive science into sociolinguistics provides us with a better understanding of the factors underpinning a sound change in progress; incorporating insights from sociolinguistics into cognitive science shows that priming does not always operate in the same way for all speakers.

1. Introduction

When we talk or write, we have a strong tendency to repeat language structures that we have recently produced or heard. This phenomenon has been variously labelled ‘recency’, ‘persistence’, ‘repetition’ and ‘priming’. The canonical methodology for investigating this involves exposing participants to two successive stimuli. The first stimulus is called the ‘prime’ and this is typically a variant form of a known linguistic variable. Following an interval, the participant is then exposed to the second stimulus, the ‘target’, to which they must respond in some way. This type of experiment has typically shown that participants’ target responses are syntactically similar to the prime (Bock 1986; Bock & Loebell 1990; Branigan et al 2000). Studies of phonological priming have often attempted to better understand how syllable structure (Foster & Davis 1991; Carreiras et al 2005; Kinoshita, 2000; Schiller, 2007) or rhyme (Meyer et al 1974; Hillinger 1980; Brooks & Macwhinney 2000) affects repetition or inhibition. Overall, the evidence from studies of phonological priming has been more discordant –some studies find strong evidence for phonological priming, especially when prime and target words share the same initial phoneme or letter (e.g. Dimitropoulou et al 2010) whereas others have only been able to replicated this finding with low-frequency words (Mousikou et al 2010).

The vast majority of priming research has come from an experimental paradigm. The question of whether this phenomenon exists in more natural dialogue has received relatively less attention. In corpus linguistics and sociolinguistics, evidence is emerging of a significant relationship between a speaker or writer’s previous use of a variable grammatical form (the prime) and the likelihood that the next instance (the target) will be the same (Gries 2005; Szmrecsanyi 2006; Poplack 1980; Travis 2007; Mayol, 2012). In studies of natural speech, discussions of the possible interaction between variation, change and phonological priming have received less attention although several recent studies have begun to explore this (Abramowicz 2007; Tammnga 2014). For the purposes of brevity, I select only two studies to illustrate this line of work.

Using a corpus of conversations collected in Scotland, Clark (2014) found that a speaker’s previous realisation of the variable TH (which can be realised as [θ] or [f]) is a good predictor of their following realisation. Furthermore, the effect was found to decay as the time increased between each instance of TH. The time decay result is shared across many studies of syntactic priming (see Pickering & Ferreira 2008) and led Clark (2014) to suggest that phonological variation in naturally occurring speech may well be susceptible to priming. Tamminga (2016) examines repetition/priming behaviour in two linguistic variables which are variously constrained by morphological factors in English. Using spoken data from the Philadelphia Neighborhood Corpus, Tamminga (2016) finds that speakers only show repetition effects if the previous word (or prime) was in the same morphological category as the target. Tamminga suggests that these findings provide tentative evidence that morphological variables are susceptible to priming but phonological variables require lexical repetition for repetition to occur.

The idea that speakers use clusters of similar variants in speech has been reported before in sociolinguistics but the suggestion has often been that repetition is under the control of the speaker as they engage in the construction and maintenance of sociolinguistic style (Eckert and Rickford 2001). Findings from Clark (2014) and Tamminga (2016) open up an intriguing possibility: that previous work invoking style as an explanation could perhaps be equally well, if not better, explained by models of priming.

However, Clark (2014) and Tamminga (2016) use spoken data from dyadic conversations where preceding variants were only considered potential primes if they were uttered by the same speaker, essentially treating dyadic conversations as if they were monologues. It is well known that the speech of two people in conversation can become more similar over time (Giles & Coupland 1991; Babel 2012; Delvaux and Soquet 2007) so by not including prime variants uttered by both interlocutors in the conversation, it is difficult to tease apart priming effects from accommodation between two talkers. Furthermore, the topic of speech can affect phonetic realization (Hay & Foulkes 2016, Love & Walker 2013). In speech that varies by topic (such as traditional sociolinguistic interviews), extra care is needed to ensure that speakers are displaying genuine priming behaviour, rather than phonetic or phonological repetition for other reasons, such as an association of a particular topic with a particular linguistic form.

To summarise, much work has shown clear priming effects at the level of grammar, both in experimental work and in natural speech. But some of the existing work in phonology has found conflicting results. This paper explores the role of priming as a motivating factor in the phonological variation that we see in natural speech with a socially-constrained sound change in progress.

2. Method

2.1 Establishing priming in natural speech

There are many reasons why repetition may occur during natural speech but there are nevertheless some clear signatures of priming. Repetition effects motivated by priming are typically “dose dependent” (Gijssels et al 2016) i.e. the more often a hearer perceives a given linguistic structure, the higher the likelihood of producing that structure. This effect also decays over time so that larger time depths between prime and target should lead to a decrease in the repetition behaviour. We also know that priming in syntax is strengthened if there is lexical repetition between the prime and target. This is the ‘lexical boost’ effect (cf. Hartsuiker et al., 2008; Jaeger & Snider 2013) in which there is stronger priming when the prime and target share the same lemma. Finally, in general, older adults are inferior to younger adults on most tasks of episodic memory, but not in priming tasks (Wiggs & Martin 1998). This means that if a repetition effect is driven by priming, we would not expect speaker age to be a significant predictor when modelling the likelihood of repetition. These effects are often indicators of priming, and so we will look for them here.

2.2 Data for the present study

The speech data come from the UC QuakeBox Corpus (see Walsh et al 2013). The corpus is uniquely suited to this research because it is a collection of monologues – 722 people volunteered to tell their story of the earthquakes in Christchurch, New Zealand. This means that priming can be explored without considering potential accommodation towards an interlocutor. Also, the topic of the monologues is relatively uniform. This provides a degree of control over the topic effect discussed above, and attempts to control for variation that may be caused by style-shifting.

2.3 Data coding

The phonological variable under examination here is the realization of word-medial, intervocalic /t/ in New Zealand English (NZE). This is a variable which is currently undergoing change with a shift away from canonical [t]. There are several phonetic realisations of this variable in NZE. Following Hay & Foulkes (2016), I categorize voiceless variants of medial /t/ (i.e. canonical released [t], and voiceless fricatives) together (shorthand = T) and voiced variants (i.e. flap and [d]) together (shorthand = D). 5063 tokens of word-medial, intervocalic /t/ from 163 speakers in the QuakeBox corpus were examined auditorily and the spectrogram of each token was inspected for acoustic signatures of voicing. These data came from a randomly selected sub-set of the full corpus because they were coded by hand, a time-consuming and labour intensive task.

All independent variables included in the statistical model predicting variation in medial /t/ are summarised in table 1.

Table 1: predictors of variation included in the statistical model predicting variation in word-medial, intervocalic /t/ in New Zealand English

	Independent Predictor Variable	Range or Values
SOCIAL	Speaker's Gender	Male/female
	Speaker's Age Group	20-80, 10-year intervals
	Log (base 10) time into recording	0.6 – 3.5
MORPHOLOGICAL	Variable at inflectional affix juncture	Yes/no
PHONOLOGICAL	Preceding /t/ in word	Yes/no
	Preceding /d/ in word	Yes/no
	Following /t/ in word	Yes/no
	Following /d/ in word	Yes/no
PHONETIC	Speech rate	0.72 – 9.52 sylls/sec
LEXICAL	Number term	Yes/no
	Log (base 10) lexical frequency	0 – 3.05
	First mention of word in discourse	Yes/no
PRIMING	Realisation of previous medial /t/	T/D
	Repetition of lexical item in previous instance of medial /t/	Yes/no
	Log time difference between prime and target	0 – 2.4

Many of the independent variables included have been reported to constrain medial /t/ by Hay & Foulkes (2016). These are: the speaker's gender and age, the speech rate of the utterance, the lexical frequency of the medial /t/ word, whether the medial /t/ word had previously occurred in the discourse, whether the medial /t/ word was a number term and whether the medial /t/ itself occurred at an inflectional affix juncture. A discussion of how these variables were coded is given in Hay & Foulkes (2016) so this will not be repeated here. One further 'social' variable is included in this model – time into the recording (log). Many sociolinguistic studies have found that socially marked linguistic features predictably increase in frequency as speakers relax into an interview. Most of these stories are short (around 10 minutes in duration) and so there is a large peak at the left of the distribution, hence this variable has been log-transformed in an effort to create a more normal distribution. Additional predictors included in this model stem from the characteristics of priming behaviour discussed above. If phonological repetition occurs in natural speech, we should expect a speaker's realisation of a phonological variable to be predictable from their previous realisation of the same variable. This is captured by: 'realisation of previous medial /t/'. If this is priming, we should also expect to see more repetition if the previous variable (prime) also occurs in the same word as the following variable (target). Finally, priming typically decays over time and so as the time increases between the prime and the target, we should perhaps expect to see less repetition.

3. Statistical modelling

3.1 Medial /t/ as D

Binomial mixed-effect models were fit to the data by hand (see Baayen et al 2008) using the lme4 package (version 1.1-10, Bates et al 2015) in R (version 3.1.2, R Core Team, 2012) with the bobyqa optimizer. The dependent variable was a binomial variable distinguishing between voiced (D) and voiceless (T) realisations of medial /t/ in NZE; (T) was set to the default as canonical [t] is the standard realisation and so the model presented here shows the log-odds of a D production. Continuous variables were first modelled as linear predictors and then checked for non-linearities using a restricted cubic spline (rms package in R, Harrell 2016). When continuous variables were found to significantly predict variation, model comparisons were used to compare linear and non-linear models (the default of 3 knots was used in non-linear models). Continuous variables were included first as uncentered values, and then with values centred on zero. In the interests of interpretability, only uncentered values are presented here. Categorical variables were treatment-coded. Model convergence issues were encountered when all possible two-way interactions were tested so only the priming variables were included in two-way interactions with all other independent variables. Three-way interactions were also checked but none were significant. The model was then pruned by removing non-significant variables and interactions. At each stage of pruning, χ^2 likelihood tests compared Akaike information criterion (Akaike 1974) and Bayesian information criterion (Schwarz 1978). Random intercepts for speaker and word were included. By-speaker random slopes were included for all significant fixed effects but this did nothing to improve the model. The model presented here includes realisation of previous medial /t/ as a slope for speaker, not because it improved the model but in an effort to control for speaker-specific repetition behaviour. Model convergence issues were encountered when by-word random slopes were included and so 'word' was only included as a random intercept. Specific details of the best-fit model are presented in table 2. This model is based on the dataset from 163 speakers. However, I was concerned that the results may be driven by speakers who display little variation. To explore this further, I removed 25% of the data from the least variable speakers (N = 3798; speakers = 122) and re-ran the model above. Both models were strikingly similar so I present results from the full dataset. Only those factors which significantly constrain the likelihood of a D realisation are included in the model in table 2.

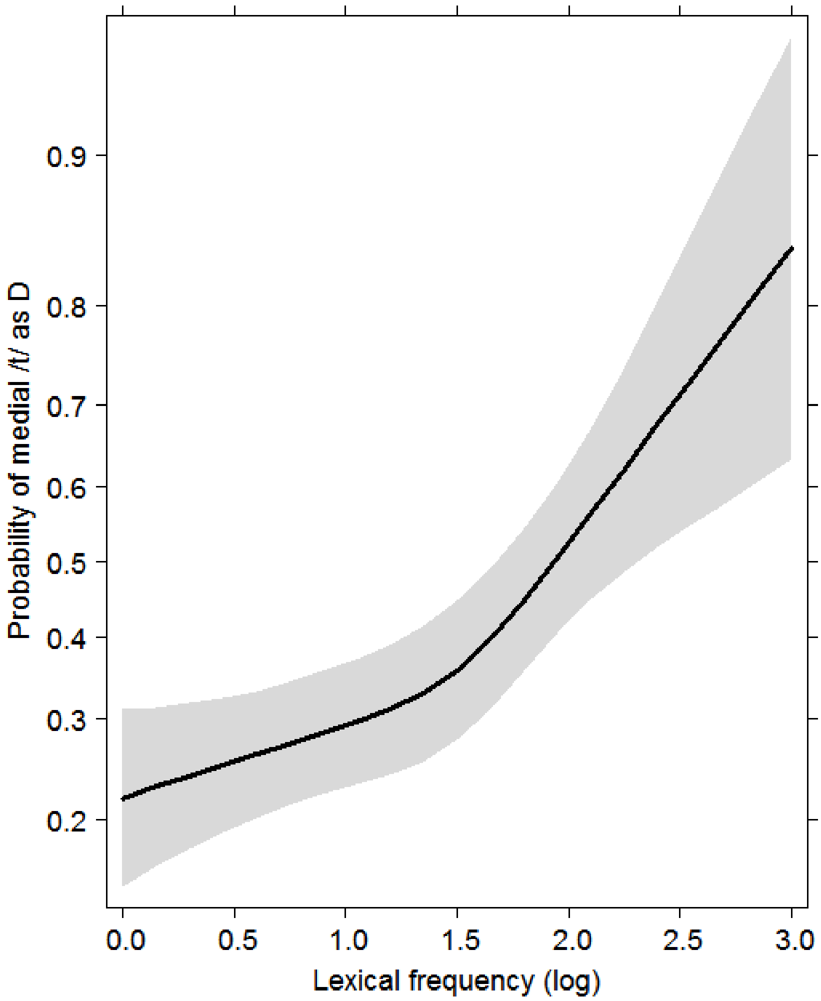
Table 2: Logistic mixed effects model of factors predicting the realisation of medial /t/ as D in word-medial, intervocalic /t/ in New Zealand English

Random effects	Variance	Std.Dev.	Corr		
Groups					
word (Intercept)	2.4655	1.5702			
speaker (Intercept)	1.3174	1.1478			
Speaker by realisation of previous medial /t/ = D random slope	0.1383	0.3719	1		
Main effects	Estimate	Std. Error	z value	Pr(>|z|)	Sig

(Intercept)	-3.38274	0.35959	-9.407	< 2e-16	***
Realisation of previous medial /t/ = D	0.55448	0.20631	2.688	0.007196	**
Repetition of lexical item in previous instance of medial /t/ = yes	-0.63128	0.18991	-3.324	8.87E-04	***
Log time difference between prime and target	0.24564	0.11975	2.051	4.02E-02	*
Speaker's Gender = Male	1.8991	0.26417	7.189	6.53E-13	***
Log lexical frequency (Restricted cubic spline knot 1)	0.39596	0.21214	1.867	6.20E-02	.
Log lexical frequency (Restricted cubic spline knot 2)	0.78048	0.38607	2.022	4.32E-02	*
First mention of word in discourse = No	0.41198	0.10519	3.917	8.98E-05	***
Speech rate	0.26465	0.05067	5.223	1.76E-07	***
Realisation of previous medial /t/ = D x Repetition of lexical item in previous instance of medial /t/ = yes	1.45609	0.27112	5.371	7.84E-08	***
Realisation of previous medial /t/ = D x Log time difference between prime and target	-0.50375	0.17076	-2.95	0.003178	**

The estimate column shows the effect of each independent variable on the log odds of D. As predicted by Hay & Foulkes (2016), there are non-interacting main effects of a speaker's gender (males produce more D than females), log lexical frequency (D is more likely in higher frequency words), repetition in discourse (D is more likely in words which have already appeared in the discourse) and speech rate (D is more likely in faster speech). The significance of these effects is shown in the final two columns. Notice that lexical frequency is the only continuous non-linear predictor so two values are reported representing the first and second points of a 3-knot restricted cubic spline. This effect is plotted in figure 1 to aid interpretability.

Figure 1: Probability of word-medial, intervocalic /t/ as D in New Zealand English by lexical frequency (log). Y axis: probability of word-medial, intervocalic /t/ as D in New Zealand English; X-axis: (log) lexical frequency of words containing word-medial, intervocalic /t/ in New Zealand English



There is also a significant main effect for the realisation of previous medial /t/. When the previous instance of medial /t/ (i.e. the prime) appears with a D realisation, the following instance of medial /t/ (i.e. the target) is also likely to appear with a D realisation. This is the main effect we would expect if there is phonological repetition in natural speech. Interestingly, this factor also enters into interactions with the other two priming variables. For clarity, these interactions are plotted in figures 2 and 3. In all plots, log odds have been converted to probabilities on the y-axes.

Figure 2: Probability of word-medial, intervocalic /t/ as D in New Zealand English interacting with the realisation of the previous medial /t/ and the previous lexical item. Y-axis: probability of word-medial, intervocalic /t/ as D in New Zealand English; X-axis: the realisation of the previous medial /t/ as either voiced (=TRUE) or voiceless (=FALSE). Top graph: the prime and target words are instances of the same lexical item; bottom graph: prime and target words are not instances of the same lexical item.

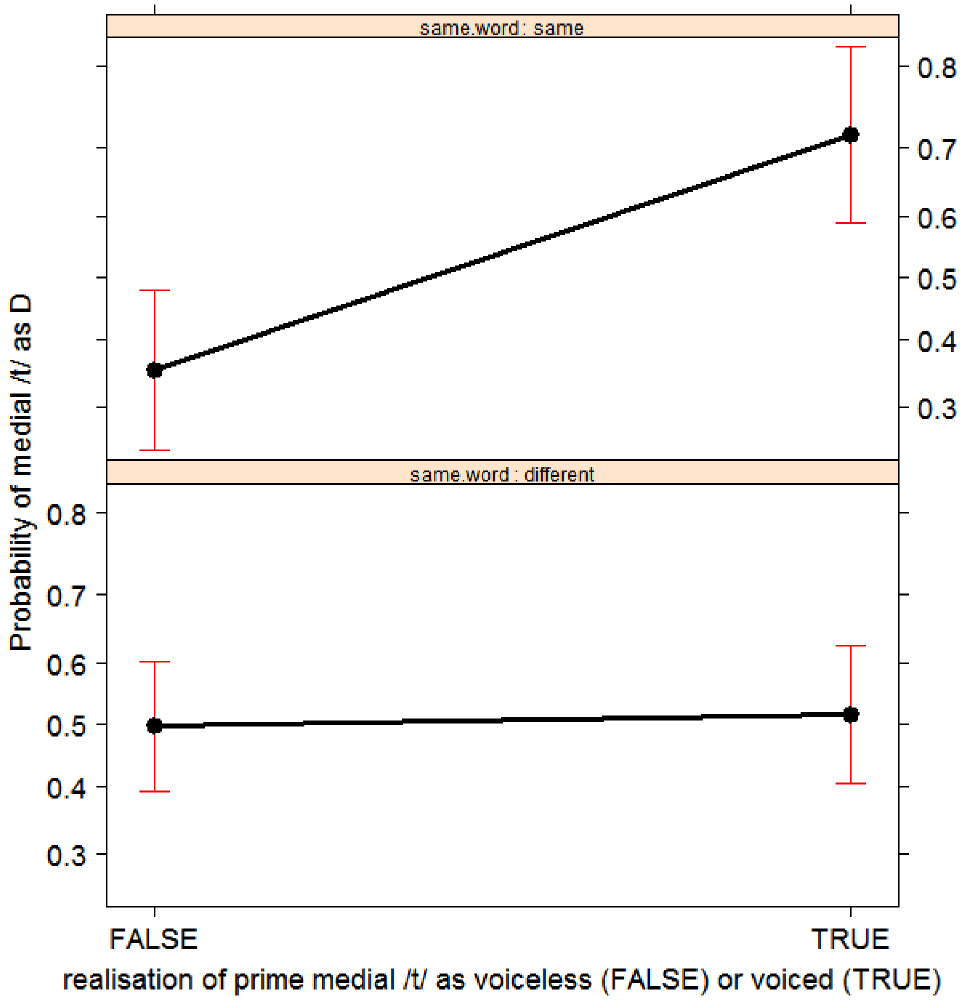


Figure 3: Probability of word-medial, intervocalic /t/ as D in New Zealand English interacting with the realisation of the previous medial /t/ and the time difference between the prime and target. Y-axis: probability of word-medial, intervocalic /t/ as D in New Zealand English; X-axis: (log) time difference between prime and target; top graph: the realisation of the previous medial /t/ is voiced (=TRUE); bottom graph = the realisation of the previous medial /t/ is voiceless (=FALSE).

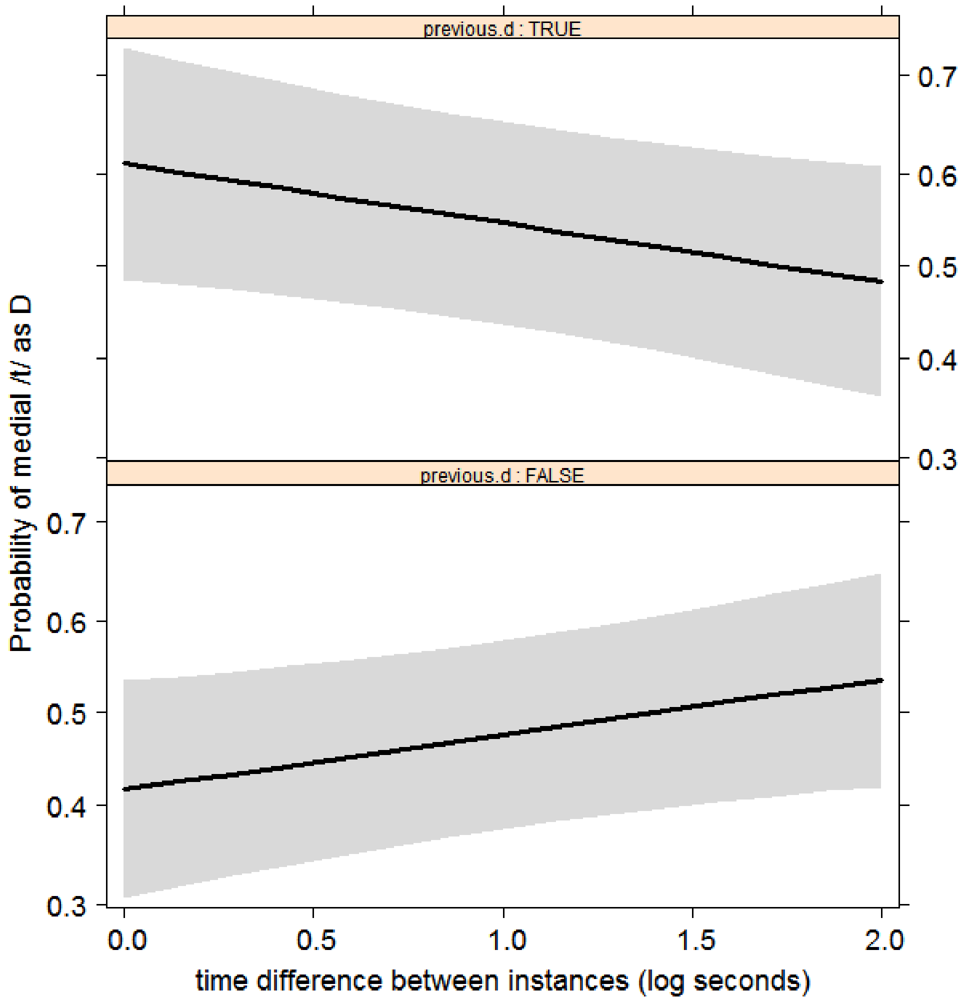


Figure 2 shows that when two instances of medial /t/ occur sequentially, and both of those instances share the same word, if the first instance is realised as voiced, the second instance is also likely to be realised as a voiced. This is reminiscent of the lexical boost effect that is characteristic of priming from experimental work (Hartsuiker et al., 2008; Jaeger & Snider 2013). In cases of lexical boost, priming increases when the prime and target are the same word but in this case, priming appears to be restricted only to these cases (as there is no difference in the likelihood of D when prime and target are in different lexical items). Figure 3 shows that as the time interval increases between two instances of medial /t/, the probability of those two consecutive instances of medial /t/ being realised as D decreases. Time here has been converted to a logarithmic scale to avoid model convergence issues created by the skewness of the time-difference data (as these data are from natural speech, there are far more data points with a shorter time difference between prime and target). In figure 3, a log time difference of 1 corresponds to around 10 seconds, and 2 corresponds to 100 seconds. This decay in the recency effect over time is again what we expect if the repetition is driven by priming. However, the three-way interaction between the realisation of previous medial /t/ x repetition of lexical item x time difference between prime and target was not significant.

This initial exploration has provided some evidence that a speaker's previous realisation of a variable phoneme does indeed influence their following realisation of that phoneme, and the two interactions shown here are consistent with an interpretation that suggests that a speaker's realisation of medial /t/ as D is at least in part motivated by priming. However, it is important to remember that D and T are categories relating to voicing and they are composed of several different phonetic variants. In the next section, I unpack these categories and explore how repetition patterns at the phonetic level.

3.2 Phonetic variants of medial /t/

Variants of medial /t/ in New Zealand fall into 4 main types: canonical articulations, fricated articulations, voiced plosives and taps (Fiasson 2015). To explore the extent to which recency effects pattern in the same way for all phonetic variants, binomial mixed-effect models were again fit to the data using the same methods as described for the model in table 2. However, this time the dependent variable was whether two consecutive variants of medial /t/ were realised with the same phonetic variant (match) or not (mismatch). Due to space restrictions, specific details of this model are in appendix 1. Only a few points of interest will be discussed here. With respect to the indicators of priming, repetition does not interact with time between prime and target in this case. The lexical boost effect is still present but only as the time into the interview progresses. And the main effect of repetition between prime and target is still apparent, but only when medial /t/ is realised as either [s] or [ɾ]. Several studies of syntactic priming have also found asymmetries related to frequency effects: low frequency constructions tend to elicit more reliable priming results. This has been called the 'inverse frequency' effect (Ferreira, 2003). Jaeger & Sneider (2013) suggest that this can be explained with surprisal: less expected structures are more attended to and so are more likely to elicit a priming effect. Here we find the opposite pattern: the two variants most likely to be immediately repeated are [ɾ] and [s], which are also the two highest frequency variants in the QuakeBox corpus. It is possible that the effect we see here is being driven by frequency: there are more tokens of [ɾ] and [s] and so the likelihood of these variants occurring in both the prime and target is higher. To explore this further, I conducted a simple Chi-square test to determine whether the likelihood of two consecutive variants of [ɾ] or [s] occurring in running speech is still higher than expected by chance. The results of this are presented in table 4. The first row of table 4 shows the number of times that the same phonetic variant appeared in both the prime and the target, and the second row shows the number of times that there was a differences (or mismatch) between the phonetic variants in the prime and the target. The columns show how this patterns across each of the 4 possible variants in the prime. The observed values of medial /t/ are on the top line of each cell, the expected number of observations is in round brackets and the chi-square statistic in square brackets for each cell.

Table 4: Distribution of the 4 variants of medial /t/ by whether the preceding variant (or prime) was an instance of the same variant (match) or not (mismatch). $\chi^2 = 439.688$, $p < 0.00001$.

	[d]	[ɾ]	[s]	[t]	Row Totals
Match between prime and target	92 (266.99) [114.69]	1124 (988.92) [18.45]	1128 (966.75) [26.90]	96 (217.35) [67.75]	2440
Mismatch between prime and target	462 (287.01) [106.69]	928 (1063.08) [17.16]	878 (1039.25) [25.02]	355 (233.65) [63.02]	2623
Column Totals	554	2052	2006	451	5063

This means that while it is possible to account for some of the recency effects observed in these data by frequency of occurrence, for both [s] and [ɾ], the observed frequency of these variants being immediately followed by another instances of the same form is still significantly higher than expected.

In interpreting this finding, it is useful to bear in mind that these data are quite unlike the data typically used in work on priming in cognitive science because this linguistic variable is undergoing a change in progress which has been shown elsewhere to be constrained by sociolinguistic factors. The focus of most sociolinguistic work on medial /t/ in NZE has been on the rise of the tap variant [ɾ], which is led by young, working class men (Holmes 1994). Fiasson (2015) examined the fricative variant [s] and showed that it too was increasing over time, but being led by women. It is therefore unsurprising that the only interaction we have in this model is between the sex of the speaker and a priming variable. For clarity, this interaction is plotted in figure 4.

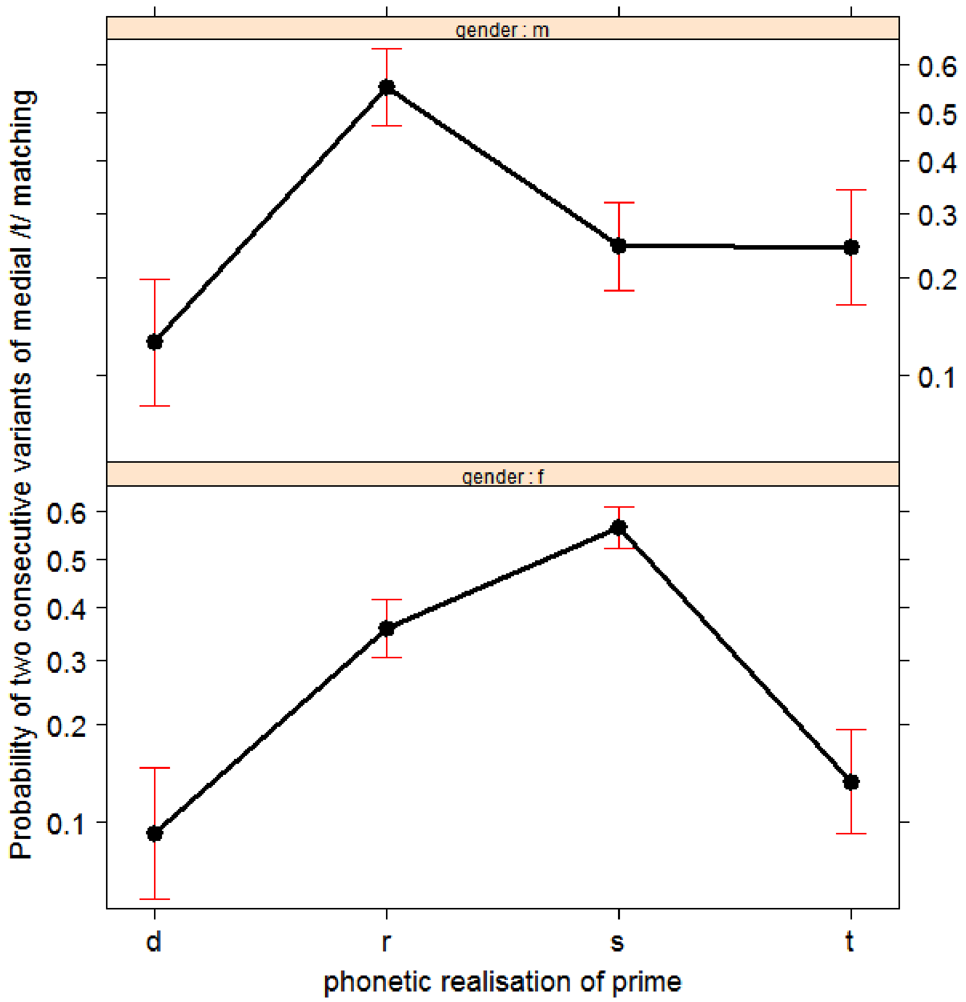


Figure 4: Probability of two consecutive variants of medial /t/ in New Zealand English having the same phonetic realisation interacting with the phonetic realisation of medial /t/ and the

speaker's gender. Y-axis: Probability of two consecutive variants of medial /t/ in New Zealand English having the same phonetic realisation; X-axis: phonetic realisation of the prime; top graph shows model output from male data and the bottom graph shows model output from female data.

Figure 4 shows that the probability of two consecutive instances of medial /t/ occurring as [s] are higher if the speaker is female (it also shows that the probability of two consecutive instances of medial /t/ occurring as [ɾ] are higher if the speaker is male, but, as we can see from appendix 1, this doesn't reach significance) . The model output reported in figure 1 shows that this interaction is highly significant and again it remains when 25% of the least variable speakers are removed (i.e. those with a strong preferance for either [ɾ] or [s]) and so this interaction between gender and repetition may point to an interesting finding about the relationship between human cognitition and the social world.

4. Linking sociolinguistics and cognitive science

This analysis has provided two main findings. First, a speaker's previous realisation of a phonological variable sometimes influences their following realisation of that variable and interacts with decay and lexical repetition in ways that are often indicative of priming. This finding should raise methodological concerns for sociolinguistics in which models of sound change often assume no relationship between instances of variation in speech. This means that a proportion of the variation that has previously been attributed to, for example, style in sociolinguistic work could potentially be attributed to more mechanistic repetition effects (see Szmrecsanyi (2006) for more on this point).

Second, arguably the more interesting finding is the interaction between repetition and the speaker's gender. Neither cognitive science nor sociolinguistics would predict this result alone, and so we need to draw on both fields in order to understand it. In cognitive science, evidence for priming phenomena is well established. Two main explanations have been suggested: spreading activation and implicit learning. However, neither of these models would predict that males and females should behave differently. On the other hand, work in sociolinguistics predicts that males and females will often display differences in speech production. During language change, women are more often the innovators and they lead change when it is below the level of conscious awareness. When the change is more salient, they favour the prestige form more than men (Labov 2001). We should therefore expect differences in the frequency of variants of medial /t/ in NZE between men and women. However, men and women from the same speech community are expected to share the same 'grammar'; that is, the linguistic constraints which operate on a sound change in progress are not expected to interact with a speaker's gender. There are two possible explanations for the finding that repetition behaviour interacts with a speaker's gender, and both rely on pooling knowledge from cognitive science and sociolinguistics:

1. Sumner (2015) has shown that our social biases modulate the allocation of cognitive resources during speech perception so that speech produced by some talkers receives more attention. When language change is in progress, linguistic variation often takes on social meaning in the community (Campbell-Kibler, 2010) making some linguistic variants more sociolinguistically salient. If the variants or exemplars which are more sociolinguistically meaningful to some speakers have heightened activation for those speakers, this then raises their chance of re-selection. Since females are leading the change to [s] in NZE we may therefore expect females to be more likely to show recency effects with [s] than other variants because for them, this is a socially more meaningful variant and so they attend to it more.

2. Within an Exemplar model (e.g. Pierrehumbert 2002), both recency and frequency add to an exemplar's activation levels. It is therefore possible that the differences we see here in priming behaviour between males and females could be driven by frequency of use and exposure. Females (as a group) are more often exposed to [s] (through a combination of their own frequent productions and that of their mostly female peer groups) and so this too would predict a difference in the priming behaviour of males and females.

By combining research on priming, which has been extensively investigated in cognitive science, with knowledge of the sociolinguistic patterning of this change in progress, it may be possible to reach a better understanding of the reasons for the interactions that we see here between a speaker's gender and their repetitive behaviour.

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Appendix 1: Logistic mixed effects model of factors predicting the same phonetic realisation between prime and target

Random effects	Variance	Std.Dev.	Corr		
Groups					
word (Intercept)	0.002003	0.04475			
speaker (Intercept)	0.783271	0.88503			
Speaker by realisation of previous medial /t/ = [ɾ] random slope	0.779998	0.88317	-0.48		1
Speaker by realisation of previous medial /t/ = [s] random slope	2.003633	1.4155	-0.95	0.22	
Speaker by realisation of previous medial /t/ = [t] random slope	0.703908	0.83899	-0.88	0.14	0.86
Main effects	Estimate	Std. Error	z value	Pr(>|z|)	Sig
(Intercept)	-2.18024	0.36716	-5.938	2.88E-09	***
Repetition of lexical item in previous instance of medial /t/ = yes	0.08841	0.57766	0.153	0.878	
Log time into the interview	-0.10109	0.0846	-1.195	0.232	
Realisation of previous medial /t/ = [ɾ]	1.72367	0.29463	5.85	4.91E-09	***
Realisation of previous medial /t/ = [s]	2.56808	0.30489	8.423	< 2.00E-16	***
Realisation of previous medial /t/ = [t]	0.43675	0.3545	1.232	0.218	
Speaker’s Gender = Male	0.37341	0.34042	1.097	0.273	
Repetition of lexical item in previous instance of medial /t/ = yes x log time into the interview	0.44816	0.22562	1.986	0.047	*
Realisation of previous medial /t/ = [ɾ] x speaker’s gender = Male	0.41751	0.35995	1.16	0.246	
Realisation of previous medial /t/ = [s] x speaker’s gender = Male	-1.76045	0.42214	-4.17	3.04E-05	***
Realisation of previous medial /t/ = [t] x	0.35471	0.42887	0.827	0.408	

speaker's gender = Male					