PRODUCTION PLANNING HYPOTHESIS: EVIDENCE FROM PALATALIZATION IN AMERICAN ENGLISH

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ABSTRACT

The study examines palatalization in American English (the Buckeye corpus) to test the predictions of the Production Planning Hypothesis: its prediction is that the rate of palatalization is positively correlated with smoothed conditional probability of the palatalizing context. We controlled for target segment, height of the vowel, grammar, speech rate, gender and age by including them as covariates in the mixed effects binomial logistic regression model.

The statistically significant effect of probability is in line with our prediction. This substantiates the claim that the size of the planning window increases the likelihood of reduction processes. Our findings provide further evidence for Production Planning Hypothesis from a non-reductory process.

Keywords: palatalization, yod coalescence, Buckeye, Production Planning Hypothesis, Smoothed Conditional Probability

1. INTRODUCTION

A number of phonetic and phonological processes operate across words. They give rise to variability in pronunciation: a speaker has a choice between the palatalized variant (*did you* /dɪdʒjə/) and the unpalatalized form (*did you* /dɪd jə/). This variability is restrained by the phonetic context of the cross word processes. The claim that speakers plan a pronunciation variant in advance, using cues from the previous and following words, is central to the Production Planning Hypothesis (PPH) [1, 2, 3, 4]. Th hypothesis does not assume that processes occur by default or at random. It presumes that processes and ensuing variants result from an interaction between planning-related predictors (e.g. the rate of speech, predictability of surrounding words, pauses) with the effects of the phonological context from surrounding words. PPH proposes that the predictors linked to speech planning are capable of modulating the size of the planning window and as such, can account for the variability encountered in pronunciation.

Previous studies have shown that in reduction processes at word junctures such as /t, d/ deletion [5] and flapping [4], the predictors of speech planning modulate the effects of the upcoming words on the preceding ones. As a consequence, this bleeds the random impact exerted by the following sounds. [5] found probabilistic effects of reduction and proved that planning the trigger word prior to planning the target word exhibits itself by higher deletion rate. The study by [4] reports that high probability of the following words is directly tied to flapping rate whereas no such link exists between predictability and glottaling process.

Our study adds the process of palatalization to redress the imbalance between widely studied reduction processes and non-reductory ones as palatalization is a special case of assimilation. We consider palatalization a good testing ground for Production Planning Hypothesis given that the process involves a significant amount of planning, i.e. more than one initial sound of the following word. In this connection, we extend the probabilistic implications to variants such as palatalized *dis yourself*. The study treats palatalization (also known as yod coalescence ([6]: 50) as an umbrella term covering a variety of assimilatory processes (see [7], [1] for a more extensive discussion on palatalization). In phonology, the change from the alveolar place of articulation in the lexical form into the post-alveolar one in the surface form is dubbed palatalization [8]. Both acoustic and articulatory oriented research takes palatalization to be a merger of two sounds, an alveolar and palatal when an increased gestural overlap occurs [9].

By palatalization we mean in this study the byproducts in the form of postalveolar fricatives /ʃ, ʒ/ and affricates /tʃ, dʒ/ if the palatal /j/ directly follows one of the alveolar consonants /t, d, s, z/. In terms of distribution, the palatalization process occurs word internally (*spiritual*) or across the boundaries of two words (*would usually*). Our study considers the latter pattern. The process results in variable outcomes and by variation, we understand the choice between two forms, palatalized (*as usual*

/æʒuʒəl/) and unpalatalized (*as usual* /æzjuʒəl/). Following the probabilistic assumptions of PPH, the research question this paper pursues is whether speakers lay palatalization out in advance and if so, what the extent of the planning strategy is. We hypothesize that both smoothed conditional probability of $word_1$ given $word_2$ and smoothed conditional probability of $word_2$ given $word_1$ will be positively associated with palatalization rate.

2. METHOD

2.1. Data

The data come from the Buckeye corpus [10] of American English. It contains approximately 40 hs of speech, nearly 307,000 word types and 9,600 word tokens. We searched for all bigrams in which $word_1$ ended with /s, z, t, d/ and $word_2$ started with /j/. Corpus querying was performed with LaBB-CAT [11], manual annotation was performed by the first author by categorizing each token (N = 2,316) as palatalized (n = 1,136) or unpalatalized (n = 1,180). Categorization followed augmented analysis (both auditory and acoustic). Unclear cases were omitted if the spectrogram revealed no cues characteristic for fricatives before /j/. Data in the .csv format and scripts are available at https://osf.io/w47d9/.

2.2. Modelling

We fit a mixed effects binary logistic regression model of whether or not palatalization occurred, using the *lme4* package [12] in R [13].

2.2.1. Test variables

Previous studies found a positive correlation between contextual probability, operationalized as transitional probability, and palatalization (e.g. [14, 15]). Our study furnishes a more precise measure of contextual predictability, i.e. the smoothed conditional probability, which better captures the characteristics of infrequent lexical items. We applied Modified Kneser-Ney smoothing [16], using the *cmscu* package [17] and trained the smoothing function on the SUBTLEX-US corpus [18]. We included the probability of $word_1$ given $word_2$ and $word_2$ given $word_1$.

2.2.2. Control variables

- Target segment: /s, z, t, d/ [19]
- Height of vowel following /j/: high /u, ʊ, ɪ/ and

non-high /ɝ, ɛ, ʌ, æ, ɑ, ɔ/ [20]
- Lexical vs. function words [21]
- Mean speech rate and speech rate deviation: [5]
- Gender, age and their interaction:gender expressed as male and female [22], age as two groups, young (up to 30) and old (above 40) [23]

We also included by-speaker and by-bigram random intercepts [24].

2.3. Results

| Fixed effects	Estimate	p value
(*Intercept*)	−4.03	0.01
scp_giv_prev	6.61	< 0.001
scp_giv_fol	8.07	0.32
targ_segs	2.11	< 0.001
targ_segt	1.31	< 0.001
targ_segz	3.08	< 0.001
vowel_heightnon−high	−1.44	< 0.001
gram_wlex_w	0.48	0.131
rate_dev	0.17	0.027
mean_rate	0.55	0.132
genderM	−0.37	0.552
ageY	−0.81	0.271
genderM : *ageY*	0.73	0.275

Table 1: Model summary: *p* values calculated with likelihood ratio tests

We hypothesized that smoothed conditional probability given previous word (scp_giv_prev) raises likelihood of palatalization across word-boundaries. As can be seen in Fig. 1, scp_giv_prev is positively associated to probability of palatalization (b = 6.6, $p < 0.05$).
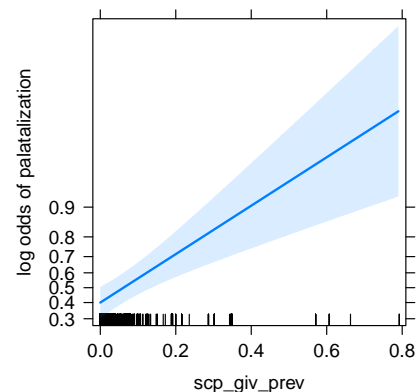
Figure 1: Partial effect plot of smoothed conditional probability of $word_2$ given $word_1$

We were also interested in the smoothed conditional probability given the following word. It turned out (Fig. 2) that the influence of the following word was not significant ($p = 0.32$).
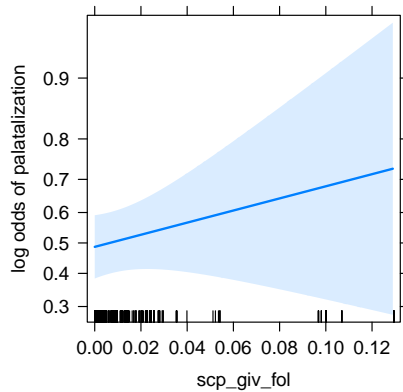
Figure 2: Partial effect plot of smoothed conditional probability of $word_1$ given $word_2$

Out of the control variables, included in our model, target segment and vowel height turned out to be statistically significant. The remaining control variables, i.e. grammar, rate deviation and mean, gender, age and the interaction between gender and did not come out as significant. For a full list of the estimates and p values, see Table 1.

Two of the control variables turned out to be significant, target segment and vowel height, and may therefore warrant further scrutiny. As for target segment, /d/ has the the lowest predicted rate of palatalization among the segments which are targets for the process. For all four target segments, see Fig. 3. Since the effects of target segment and vowel height do not directly pertain to our hypothesis, we do not discuss them further here.

Regarding vowel height, high vowels have a higher predicted rate of palatalization than non-high vowels do (see Fig. 4).

3. DISCUSSION

Production Planning Hypothesis assumes that the speaker plans articulation in advance as the application of processes does not happen by default [2], [4]. As a consequence, the speaker may choose the variant using cues from e.g. the preceding and following context, especially in processes which span word boundaries.

In our study, we aimed to extend the ramifications of the PPH on palatalization. So far, PPH has studied reduction processes such as liaison
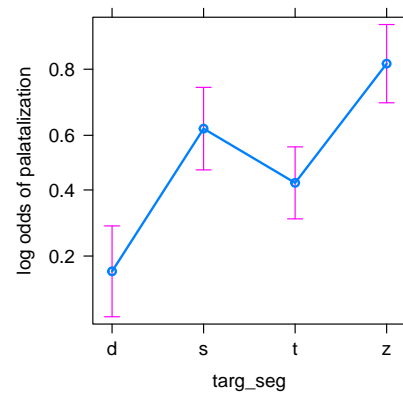
Figure 3: Partial effect plot of target segment identity
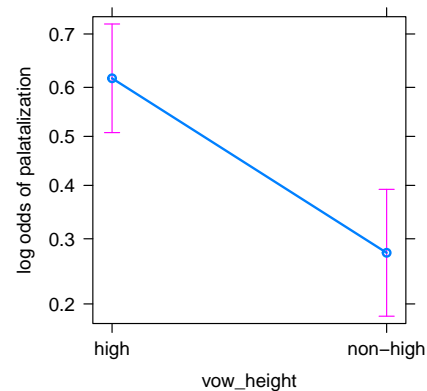
Figure 4: Partial effect plot of the vowel height

in French, flapping and /t,d/ deletion in English. Our contribution to the PPH is to test the planning window on a non-reductory process, i.e. palatalization.

We have positively verified our hypothesis, deriving from PPH, that smoothed conditional probability has a significant effect on palatalization, cf. Fig. 1. This validates the claim that the speakers from the Buckeye corpus indeed selected to apply palatalization in the target word in the situation where $word_2$ is predictable from $word_1$.

The other operationalization of contextual probability, that is the predictability of the $word_1$ given $word_2$ did not turn out to be significant. The latter was found for reduction of word duration [25] and perhaps the fact that ours is a non-reductory process, explains the discrepancy between ours and [25]'s result. Further support for this observation comes from [4] who found such effect for flapping

where sounds do not assimilate and substantiates our suggestion that reduction processes pattern differently from coalescence processes.

We have also observed a statistically significant effect of vowel height on palatalization [20], in that the high vowel group increased the probability of a palatalized variant, unlike the non-high vowels. This is a very promising outcome for PPH as we demonstrate that palatalization is sensitive to the height of the following vowel and as such, takes the following vowel to be a part of the planning window.

This result offers an interesting testing ground for PPH if we consider in a future study an interaction of smoothed conditional probability and vowel height. If the effect of the vowel is larger for higher scp values and smaller for lower scp values, it would constitute another piece of evidence that the size of the planning window is adaptable and truly context-sensitive.

4. CONCLUSIONS

Firstly, we found that in their choice of a pronunciation variant, speakers are informed by the predictability of the earlier phonetic material, relative to the target word. This provides evidence for Production Planning Hypothesis by establishing the size of the planning window: it spans the predictability of the preceding but not the following word. Secondly, vowel height predicts whether a variant is palatalized or not which seems to imply that speakers plan in advance to palatalize given the category of the upcoming vowel following /j/. We suggest that other processes may be tested within the frameworks of Production Planning Hypothesis to shed more light on speech planning. Another implication is to find a possible interaction between the vowel height and smoothed conditional probability given the previous word to produce a more comprehensive and explanatory model which captures palatalization in the probabilistic paradigm.

5. REFERENCES

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