

## Larger phonological planning windows trigger variation in word-final consonants

Oriana Kilbourn-Ceron and Matthew Goldrick, Northwestern University

In spontaneous speech, word pronunciations can vary considerably, even within individual speakers. The final /t/ in “great,” for example, could be realized as [t], [ʔ], or (in many varieties of English) [ɾ]. Some of these word-final allophones are conditioned on the phonological structure of a following word: a word-final /t/ is likely to be a flap if a word-initial vowel follows, e.g. “grea[ɾ] exam,” but these generalizations are gradient, especially in conversational speech.

**Hypothesis** Following recent work (Kilbourn-Ceron, 2017; Tamminga et al., 2016; Tanner et al., 2017; Wagner, 2012), we propose that this variation is partly attributable to the size of the planning window in phonological encoding. Using flapping as a test case, we hypothesize that when incremental production is emphasized, the planning window may span only the first word. This will block the occurrence of flapping; a word-final /t/ will flap only if the intervocalic environment is specified during planning of the first word. Previous work in spontaneous speech has shown that variables that facilitate advance planning (e.g., higher lexical frequency of the following word; Jescheniak and Levelt, 1994) are correlated with the appearance of word-final allophones triggered by the phonological structure of following words (e.g., “grea[ɾ]” is more likely to occur if the following word is frequent; Kilbourn-Ceron et al., 2016). We test the hypothesized causal relationship between planning and variation in a pre-registered, randomized-control production study.

**Methods** Data and analysis scripts are available at OSF. Sample size (40 items, 50 participants) was determined via a Monte Carlo power analysis, using effect sizes from previous work (Kilbourn-Ceron et al., 2016). Participants read aloud adjective-noun phrases (e.g., *great exam*) with low collocational frequency (Michel et al., 2011). Each adjective appeared with three critical vowel-initial nouns of different frequencies (based on SUBTLEX-US counts; Brysbaert and New, 2009). Participants were asked to begin speaking as quickly as possible to encourage an incremental planning strategy. We predicted that conditions favoring advanced planning of the second word (higher frequency adjectives and nouns, shorter adjectives) would increase the likelihood of flapping. Recordings were force-aligned (McAuliffe et al., 2017), and acoustically analyzed in Praat (Boersma and Weenink, 2019). The dependent measure was a binary variable with 1 indicating over 90% of the /t/ interval was voiced. This cutoff was chosen because it yielded the best balanced accuracy score (0.88) when compared against 591 tokens perceptually annotated by the first author.

A mixed-effects logistic regression (Bates et al., 2013; R Core Team, 2013) was fit to the data ( $N = 10,033$ ), with the maximum identifiable random effect structure by participant and item. Fixed effects include adjective and noun frequency, adjective syllable length, and all interactions. Speech rate (phones/second) and block number were included as controls.

**Results** Results are shown in Figures 1 and 2. As predicted, high frequency nouns resulted in significantly more flaps. ( $\hat{\beta} = 0.504, p < 0.001$ ). The same pattern held for adjective frequency ( $\hat{\beta} = 0.0565, p = 0.005$ ). These two factors interacted, such that noun frequency effects were magnified for higher frequency adjectives ( $\hat{\beta} = 0.471, p = 0.032$ ). The number of syllables in the adjective was not significant, nor were any other interactions.

**Discussion** The results of our study provide stronger evidence that the size of the speech production planning window is causally related to variability in the realization of word-final consonants. We are currently examining flapping when participants are forced to delay onset of articulation. This should encourage wider planning scope, increasing flapping overall and reducing the effects of noun and adjective frequency.

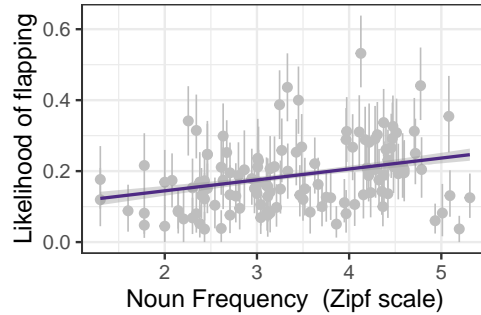


Figure 1: Empirical correlation between proportion of observations with flap (>90% voicing during closure) in the final segment of the adjective and frequency (Zipf scale; Van Heuven et al., 2014) of the following vowel-initial noun. Points in gray show mean values by bigram, with bootstrapped confidence intervals.

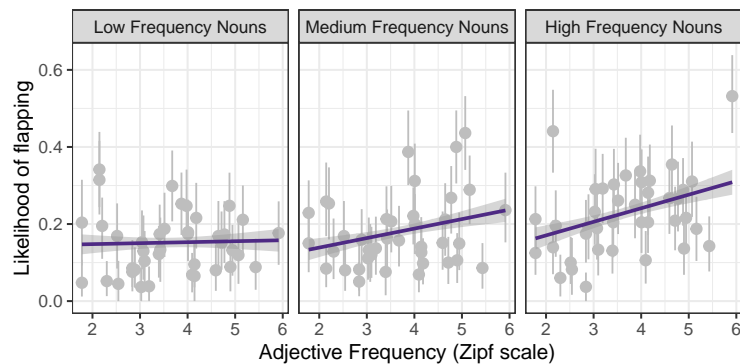


Figure 2: Empirical correlation between proportion of observations with flap (>90% voicing during closure) in the final segment of the adjective and frequency (Zipf scale; Van Heuven et al., 2014) of the adjective. Separate smooths are fit for each noun frequency condition, i.e. each adjective appears in a single bigram in each panel. Points show mean values by bigram, with bootstrapped confidence intervals.

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