Incomplete Neutralization in American English Flapping: A Production Study

Aaron Braver | Rutgers, The State University of New Jersey

Introduction: Flapping, the process by which intervocalic /t/ and /d/ shorten in American English, has been used to argue both in favor of and against the existence of incomplete neutralization. In *complete* neutralization, two underlyingly distinct segments merge to the same output segment, and are produced identically. In *incomplete* neutralization, however, segments that have merged phonologically are produced with slight phonetic variation (see, e.g., Port and O'Dell (1985)). While some studies of flapping in American English report that the process completely neutralizes underlying /t/ and /d/ to [ɾ] (e.g. Joos 1942), others report that the underlying voicing status of a flap—that is, whether it originated from a /t/ or a /d/—can be determined from the phonetic output (Fisher and Hirsh 1976, among others).

This study attempts to reconcile these conflicting reports by answering the following questions: (i) is flapping an instance of incomplete neutralization? (ii) if so, what trace of the underlying distinction between /t/ and /d/ remains in the phonetics? (iii) does the degree of neutralization vary with experimental design?

Method: The experiment had two tasks. In the minimal pair reading task, speakers were shown 30 nonce-words comprising minimal pairs differing only in whether they contained intervocalic /t/ or /d/. The pairs were placed in frame sentences, mixed with 20 distractors, and randomized. Speakers were then directed to read each pair aloud casually from a screen.

A morphological paradigm completion ('wug') task was also conducted. This task minimizes the likelihood of hyperarticulation (and thus, lack of flapping), as well as the influence of orthography associated with minimal pair reading tasks. In this task, speakers were shown 30 nonce-words—15 with word-final /t/ and 15 with word-final /d/. The tokens were mixed with 30 distractors and randomized. Speakers were shown each nonce word in a frame sentence that unambiguously identified it as a verb. They were then shown a second frame sentence with a blank into which they were instructed to insert the '-ing' form of the verb—thus making word-final /t/ and /d/ word-medial, and thereby placing them into a flapping environment.

Each speaker was recorded in a soundproof booth, with recordings digitized as WAV files at a sampling rate of 44.1kHz. For each task, the duration of each flapped segment, as well as the duration of the preceding vowel, was measured using Praat (Boersma and Weenink 2009).

Results and discussion: The results appear in Figures 1–4. Figure 1 shows the mean duration of flaps for each task. Figure 2 shows the difference between the mean duration of /d/-flaps and that of /t/-flaps. Figures 3 and 4 show the same for vowel duration. Statistical comparisons are listed in Table 1. (i) The duration of /d/ flaps and that of /t/ flaps was significantly different ($p<0.01$), suggesting that the neutralization in flapping is, indeed, incomplete. (ii) While flap duration, then, serves as a trace of the underlying voicing distinction, no significant effect was found on the duration of the preceding vowel, contrary to previous studies (Fox and Terbeek 1977). (iii) Further, the results show a significant ($p<0.05$) effect of the interaction between task and underlying voicing status on flap duration, suggesting a task effect on the degree of neutralization. This can be seen in Figure 2, which shows that /d/-flaps were more different from /t/-flaps in the minimal pair reading task than they were in the wug task. Interestingly, the direction of distinction in flap duration varied with task as well—/t/ flaps were longer in the wug task, while /d/ flaps were longer in the minimal pair reading task. This latter finding is surprising, as voiceless segments generally tend to have a greater duration than voiced segments in non-neutralizing contexts (Stevens et al. 1986).

These findings suggest that some degree of incomplete neutralization is, in fact, observed in flapping. Additionally, the existence of a task effect may explain the discrepancy among earlier studies, which did not have identical experimental procedures. Further, these results add to the growing body of work (e.g., Fourakis and Iverson (1984), Warner et al. (2006)) which suggests that debates regarding incomplete neutralization in a given phenomenon may be resolved once the effects of experimental design are taken into consideration.

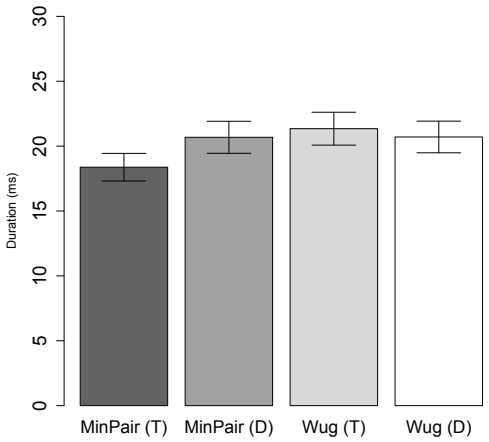

Figure 1: Mean flap duration by condition (All error bars: 95% confidence)

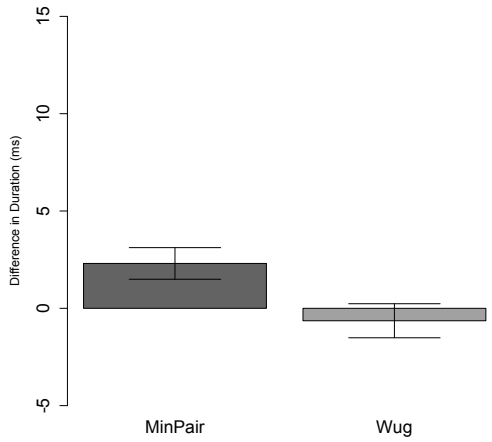

Figure 2: Difference of mean /t/-flap from mean /d/-flap duration, by task

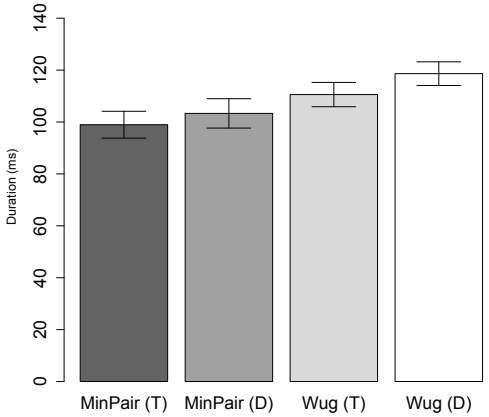

Figure 3: Mean vowel duration by condition

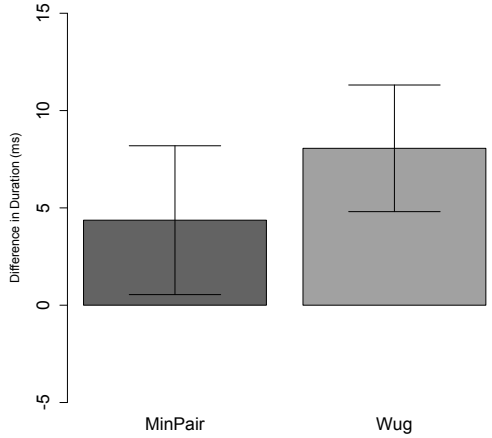

Figure 4: Difference of mean pre-/t/ vowel from mean pre-/d/ vowel duration, by task

Effect of	*On*	*t*	*p*
Underlying voicing	flap duration	-2.485	<.01
	vowel duration	-0.429	*n.s.*
Interaction of underlying voicing and task	flap duration	2.012	<.05
	vowel duration	-0.029	*n.s.*

Table 1: The results of a mixed linear model analysis (Baayen 2008). Vowel duration and flap duration were regressed against a model in which underlying voicing status, task, and vowel quality were fixed factors, and speaker and item were random factors.

Selected References

Fourakis, Marios and Iverson, Gregory (1984). *On the 'Incomplete Neutralization' of German Final Obstruents*. Phonetica 41:140–149.

Fox, Robert A. and Terbeek, Dale (1977). *Dental Flaps, Vowel Duration, and Rule Ordering in American English*. Journal of Phonetics 5:27–34.

Joos, Martin (1942). *A Phonological Dilemma in Canadian English*. Language 18(2):141–144.

Port, Robert and O'Dell, Michael (1985). *Neutralization and Syllable-Final Voicing in German*. Journal of Phonetics 13:455–471.

Warner, Natasha; Good, Erin; Jongman, Allard; and Sereno, Joan (2006). *Orthographic vs. Morphological Incomplete Neutralization Effects*. Journal of Phonetics 34(2):285–293.