



# Perception of Incompletely Neutralized /d/ and /t/ Flaps in AmE

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## Introduction

- **Incomplete Neutralization (IN)**
  - /X/ → [Z<sup>X</sup>] / (Context A)
  - /Y/ → [Z<sup>Y</sup>] / (Context A)
  - Final devoicing is a commonly cited case of *IN*.
- **AmE Flapping** is a potential case of *IN*:
  - /t/ and /d/ become [ɾ] in certain prosodic configurations (Kahn 1980), but distinctions remain on the surface.
  - Most notably, **vowels before /d/-flaps are longer than vowels before /t/-flaps** (Braver 2011, Herd et al. 2010) (though see Port (1976)).
  - This distinction is generally less than 10ms.

## Background, Questions, and Motivation

- **Perception studies of IN show mixed results:**
  - Port and O'Dell (1985), Warner et al. (2004): listeners can perceive the difference between *IN* segments.
  - Herd et al. (2010) present an identification task showing that listeners cannot correctly categorize /d/-flaps and /t/-flaps in actual AmE words.
- **Three questions:**
  1. Can AmE listeners *categorize* /d/-flaps and /t/-flaps?
  2. Can they *distinguish* /d/-flaps from /t/-flaps?
  3. Why do (some) speakers produce this distinction?
- Previous studies addressing these questions leave a number of issues open.
  1. They generally rely on actual words of a language, potentially introducing frequency bias on perceptual categorization.
  2. Even though listeners have a general bias towards /d/ (Herd et al. 2010), measures of performance do not take this into account.
  3. Most studies have relied solely on identification tasks (as opposed to discrimination tasks).
- Contributions of this study:
  - Shows that **AmE listeners can neither discriminate nor properly categorize /d/-flaps from /t/-flaps on the basis of category.**
  - Addresses concerns of frequency effects through the use of nonce word stimuli.
  - Addresses issues of bias through the use of *d'* as a measure of performance.

## Stimuli

- Tokens were trisyllabic nonce words taken from a related production experiment (Braver 2011).
  - 12 speakers produced each token in two tasks (no significant differences were found across tasks):
  - $\sigma$  1: onsets {p,t,b,d}, nuclei: ə
  - $\sigma$  2: onsets {p,t,k}, nuclei: {i, ε, æ}, codas: {d,t}
  - $\sigma$  3: '-ing' (places d/t in flapping environment)
- Some representative minimal pairs:
 

puhPEET-ing	puhPEED-ing
tuhKAT-ing	tuhKAD-ing
duhTEHT-ing	duhTEHD-ing
- Tokens were selected from three speakers, based on the following criteria:
  - Largest difference between pre-/d/ and pre-/t/ vowel duration.
  - Accurate production of a sufficient number of tokens.
  - Balanced for onset and vowel of target syllable, as well as /d/ vs. /t/.

## Methods, Part I

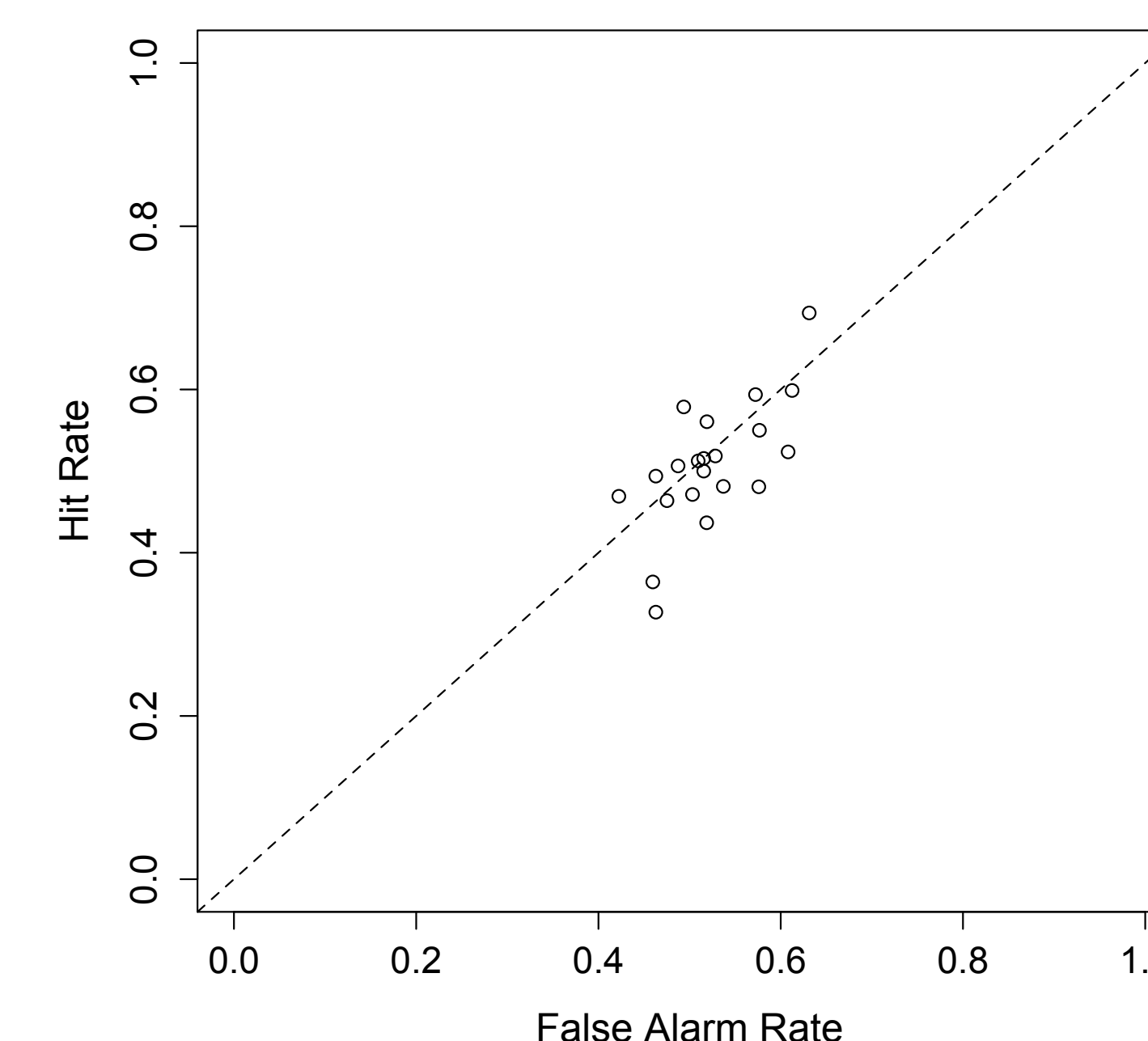
- 42 undergraduates participated in two tasks (21 per task).
- Feedback was given on each trial.
- Three blocks, each from a different speaker.
  - Block order was balanced (Latin Square) across all listeners.
- **Identification Task:**
  - Listeners heard a single token, and were asked whether the sound before the '-ing' was a /d/ or a /t/.
- **ABX Task:**
  - Listeners heard three stimuli per trial (A, B, then, X), and were asked to decide whether X was the same as A or the same as B.
  - A relatively long ISI (500ms) was used between sounds B and X with the goal of inducing a categorical, rather than purely auditory mode of perception.

## Results, Part I

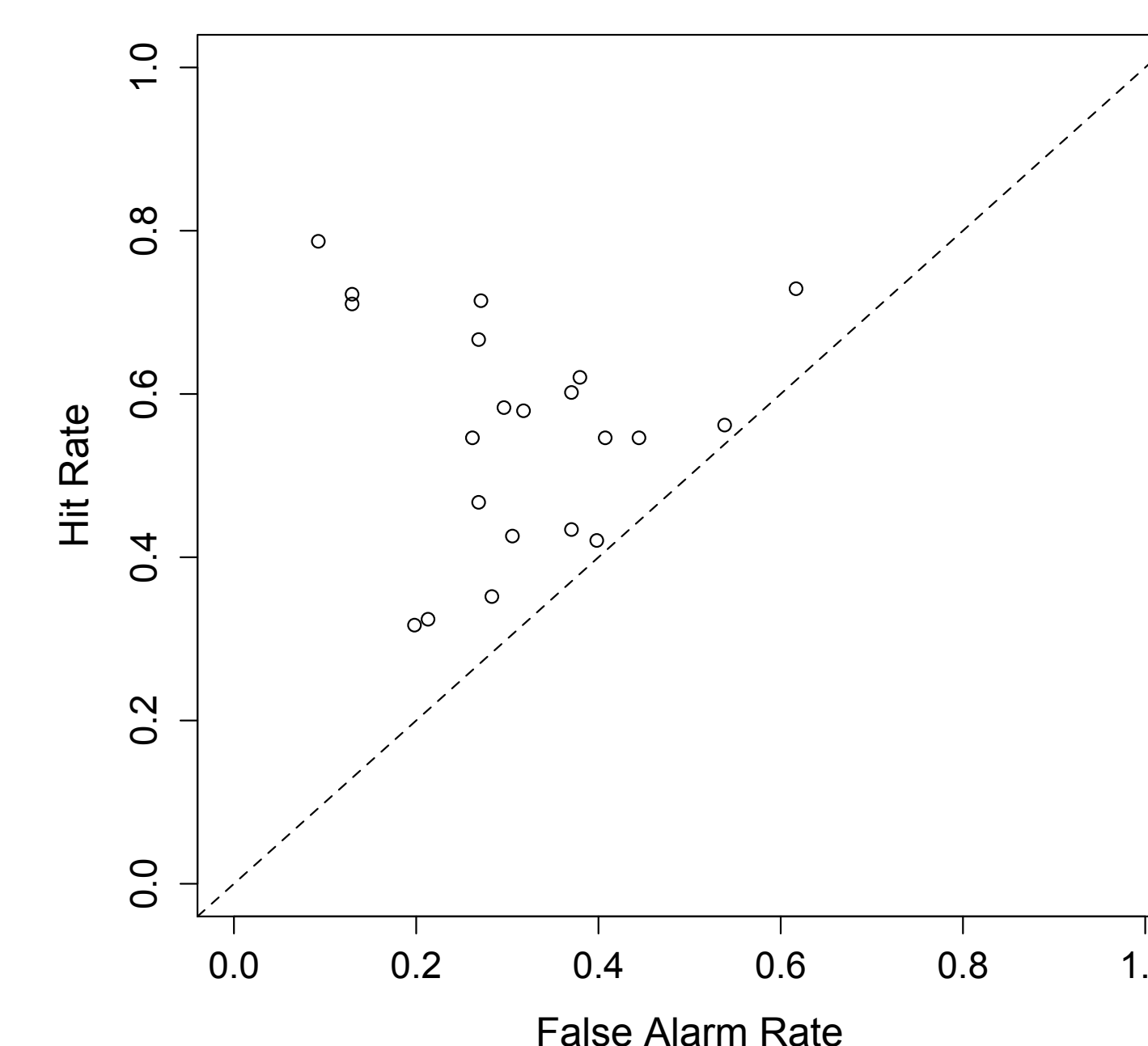
- **Identification Task:**
  - Listeners' *d'* scores were not significantly different from 0 (mean *d'*: -0.04, Wilcoxon test:  $V = 76, n.s.$ ).
  - Listeners said "it's a /d/" just as often when they had heard a /d/ as when they had heard a /t/.

## Results, Part 1 (Continued)

- **Hits vs. False Alarms for the Identification Task:**



- **ABX Task:**
  - Listeners' *d'* scores were significantly different from 0 (mean *d'*: 1.24, Wilcoxon test:  $V = 231, p < 0.001$ ).
  - Listeners said "X is like A" more often when X was actually like A than when X was actually like B.
- **Hits vs. False Alarms for the ABX Task:**



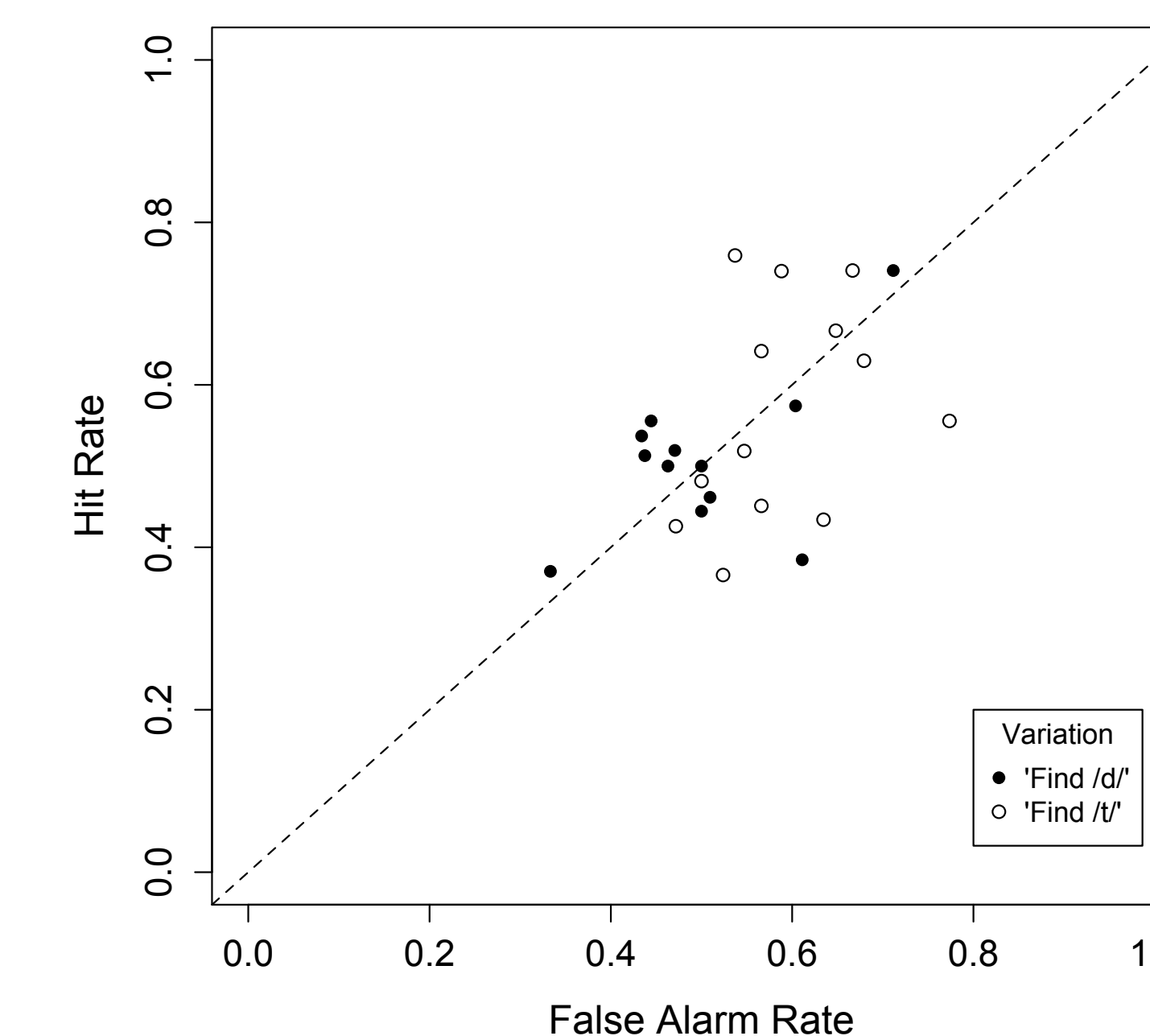
- **Why did listeners do better in the ABX task than the Identification Task?**
  - Listeners anecdotally reported using cues unrelated to the /t/~d/ distinction (e.g., intonation contour).

## Methods, Part II

- To test whether listeners discriminated based on irrelevant acoustic differences between A and B in the ABX task, an **AB Task** (a.k.a 2AFC) was run.
  - Allows for comparisons (like the ABX task), but no two tokens are the same on a given trial (like the ID task).
- 21 listeners heard two tokens (from the same set as the previous tasks) per trial.
  - Half of the trials had /d/ first and half had /t/ first.

## Results, Part II

- In the **AB task**, listeners' *d'* scores were not significantly different from 0 (mean *d'*: -0.02, Wilcoxon test  $V = 148, n.s.$ ).
- **Hits vs. False Alarms for the AB Task:**



## Discussion and Conclusions

- The low *d'* scores in the identification task suggest that listeners were unable to categorize /d/-flaps and /t/-flaps.
- While listeners were able to distinguish /d/-tokens from /t/-tokens in the ABX task, they were unable to do this in the AB task where they heard only two sounds per trial, which are never identical.
  - Speakers were unable to use the 'unrelated cues' strategy in the AB task, suggesting that listeners cannot distinguish /d/-flaps from /t/-flaps on the basis of cues relevant to the underlying voicing contrast.
- These results hold in both an identification and a discrimination task, and when frequency effects are mitigated through the use of nonce words.
- If listeners are neither able to distinguish nor categorize /d/-flaps and /t/-flaps, speakers who maintain this distinction must be doing so for reasons other than listeners' benefit.

## Selected References

- A. Braver 2011. *Incomplete Neutralization in American English Flapping: A Production Study*. In PLC Proceedings 34 <http://repository.upenn.edu/pwpl/vol117/iss1/5/>
- R. Port and M. O'Dell 1985. *Neutralization and Syllable-Final Voicing in German*. JPhon 13:455-471
- W. Herd, A. Jongman, and J. Sereno 2010. *An Acoustic and Perceptual Analysis of /t/ and /d/ flaps in American English*. JPhon 38:504-516

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