(Im)perceptible Incomplete Neutralization

Two experiments on flapping in American English

Aaron Braver
abraver@rutgers.edu

RUMMIT II
16 May, 2011

What I'll be talking about

- Background
  - Incomplete neutralization
  - Some previous studies
- The perception experiments
  - Identification
  - ABX
- What does it mean?
  - Implications for incomplete neutralization

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Background

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Complete neutralization

- /X/ → [Z] / (Context A)
- /Y/ → [Z] / (Context A)

- The traditional picture of German final devoicing:
  - /ʁɑt/ 'advice'
  - /ʁɑd/ 'wheel'

→ [ʁɑt]

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Incomplete neutralization

- /X/ → [Z^X] / (Context A)
- /Y/ → [Z^Y] / (Context A)

- The picture of German final devoicing from acoustic studies (Port and O'Dell 1985, though see Fourakis and Iverson 1984)
  - /ʁɑt/ 'advice' ——— [ʁɑt]
  - /ʁɑd/ 'wheel' ——— [ʁɑ·t]

(For similar results in other final devoicing languages, see Dinnsen and Charles-Luce (1984), Slowiaczek and Dinnsen (1985), Slowiaczek and Szymanska (1989), Warner et al. (2004), though see Warner et al. (2006))

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Flapping

Completely neutralizing

writer → [ɹaiɾə·]
rider →

OR ?

Incompletely neutralizing

writer ——— [ɹaiɾə·]
rider ——— [ɹai·ɾə·]

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My production studies

- Acoustic study 1 (Braver 2010, 2011)
  - 13 speakers
  - Pre-/d/ vowels longer than pre-/t/ vowels (8.76ms)
- Acoustic study 2 (Braver 2010, 2011)
  - 12 speakers
  - Pre-/d/ vowels longer than pre-/t/ vowels (3.45ms)
- The neutralization is incomplete

(See also Fisher and Hirsh (1976), Fox and Terbeek (1977), Zue and Laferriere (1979), Huff (1980), Herd et al. (2010). But, see (partially) contrary results in Joos (1942), Port (1976))

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The question

- Speakers produce a distinction between /d/-flaps and /t/-flaps…
- …but this distinction is tiny
- Can listeners perceive this distinction?

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Herd et al. 2010

- Production task:
  - Pre-/d/-flap vowels were 6ms longer than pre-/t/-flap vowels

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Herd et al. 2010

- Identification task
  - Listeners heard a word, and were asked which of two words on the screen it was:
    - Hear: [liɾə]
    - See: "liter" "leader"

(For previous perception studies of incomplete neutralization in non-flapping contexts, see Port and O'Dell (1985), Warner et al. (2004))

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Herd et al. 2010

- How did they do?
  - Near chance
  - /d/ tokens were correctly identified more frequently than /t/ tokens
  - Lexical frequency effects
    - Low frequency /t/ words: 33% correct
    - High frequency /t/ words: 55% correct
- /d/-bias and frequency bias (Connine et al. 1993), rather than preceding vowel duration, help determine listeners' responses

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Motivation for the current experiments

- Mitigate frequency effects
  - Nonce words
- How hard is the task itself?
  - ID and ABX
  - Feedback
- Keep bias in mind during analysis

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The perception experiments

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Two tasks

- Identification
  - Did that word have a /d/ or a /t/ in the target location?
- ABX
  - Was word X the same as word A or word B?

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The tokens

- Nonce words
  - First syllable: unstressed
    - Onsets: p/t/b/d
    - Nucleus: **ə**
  - Second (target) syllable
    - Onsets: p/t/k
    - Nuclei: i/**ɛ**/æ
    - Coda: d/t

Some representative minimal pairs	
puhPEET-ing	puhPEED-ing
tuhKAT-ing	tuhKAD-ing
duhTAT-ing	duhTAD-ing

- "-ing" was added to each bisyllabic nonce word, putting the final /d/ or /t/ in a flapping environment

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The tokens

- Taken from speakers in the 2nd acoustic study
- 12 speakers produced each token in 2 tasks
  - "Wug" task (Berko 1958, Fourakis and Iverson 1984)
    - John learned how to buhKEED this week. He was _____ this whole week.
      - Speakers read the sentences, filling in the "-ing" form—e.g., "buhKEEDing"
  - Minimal pair reading task
    - John learned how to buhKEED this week. He was buhKEEDing this whole week.
    - John learned how to buhKEET this week. He was buhKEETing this whole week.
  - No significant differences across tasks

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The tokens

- Tokens were selected from three speakers who had the biggest difference between pre-/d/ and pre-/t/ vowel duration, and who accurately produced a sufficient number of tokens
- Balanced for onset and vowel of target syllable, as well as /d/ vs. /t/

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Identification

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Identification

- Instructions and practice with real and nonce words
- 3 blocks, each from different speakers
- Each block had 36 tokens (half /d/, half /t/), randomized, repeated 3 times (=108 per block)
- Feedback on each trial
- Break between each block
- Order of blocks balanced (Latin Square) across 21 listeners

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Identification trials

- Trial 1 **t**
- Trial 2 **d**
- Trial 3 **t**

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How well did listeners do?

- Percent-correct
  - "Listeners identified X from Y more than 50% of the time"
  - But:
    - How biased were the speakers towards X or Y?
    - Herd et al.'s listeners were biased towards saying /d/, and as such /d/ has a high percent correct rate
      - But does this mean that /d/ was more perceptible than /t/?

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d′ for the intelligent non-psychophysicist

What the operator says is happening

What's actually happening

	"Missile"	"No missile"
Missile!	Hit	Miss (uh oh)
No Missile	False alarm	Correct rejection

- Hit rate
  - When there's a missile, how often do they say "missile!"?
- False alarm rate
  - When there's no missile, how often do they say "missile!"?

(Macmillan and Creelman 2005)

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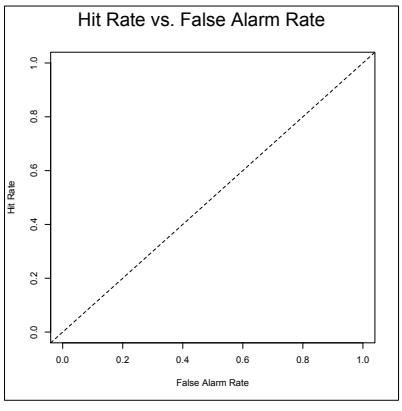

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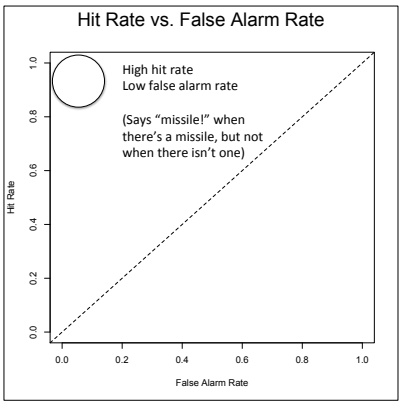

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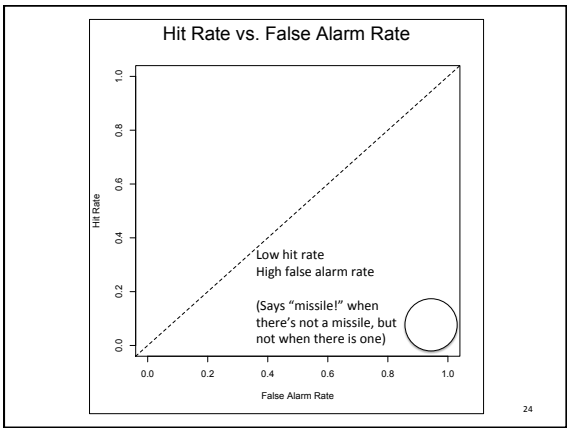

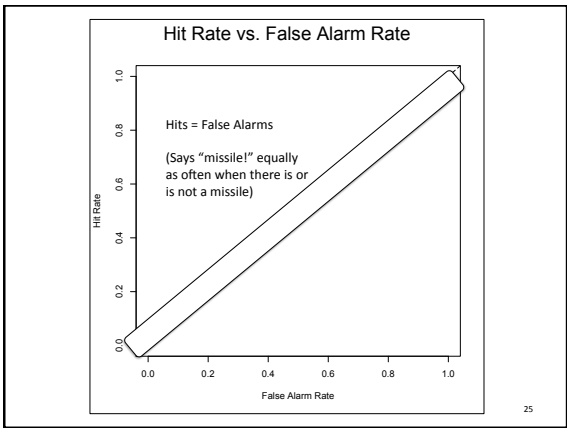

d' for ID

		What the listener says they heard	
		"That was a /d/"	"That was a /t/"
What's actually happening	Hear /d/	Hit	Miss (uh oh)
	Hear /t/	False alarm	Correct rejection

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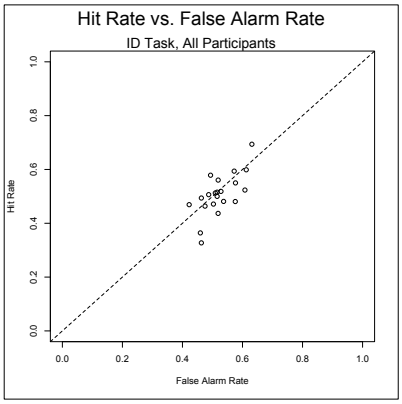

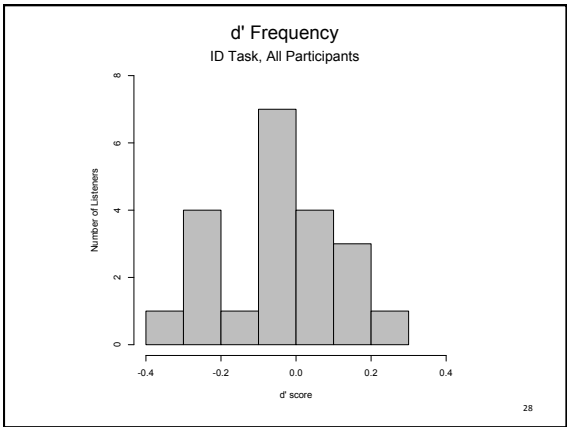

ID results

- **d' is not significantly different from 0 overall** (mean d': -0.04, Wilcoxon test: V=76, n.s.)
- So—listeners said "it's a d" about the same number of times for /d/ as for /t/
- (If these were missiles, we'd be in trouble)

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ABX

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What's ABX?

- Three stimuli per trial (A, then B, then X)
- Participants decide whether the third (X) was the same as A or as B

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ABX

- Instructions and practice with real and nonce words
- 3 blocks, each from different speakers
- Each block had 72 trials (18 each of d-t-t, d-t-d, t-d-d, t-d-t), randomized
- Feedback on each trial
- Break between each block
- Order of blocks balanced (Latin Square) across 21 listeners

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ABX: ISI

A (250ms) B (500ms) X

- Longer B-X ISI to induce categorical, rather than auditory mode of perception
  (in the sense of Gerrits and Schouten 2004)
- Goal: get at a categorical distinction, using an easier task than identification
  - Category labeling takes place after 100-200ms
  - Discrimination performance reaches a maximum between 500–1000ms

(Gerrits and Schouten 2004)

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ABX trials

- A (250ms) B (500ms) X
- Trial 1  A (d t d)
- Trial 2  B (t d d)
- Trial 3  B (t d d)
- Trial 4  A (t d t)

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d′ for ABX

What's actually happening	*What the listener says is happening*	
	"X = A"	"X = B"
X = A	Hit	Miss (uh oh)
X = B	False alarm	Correct rejection

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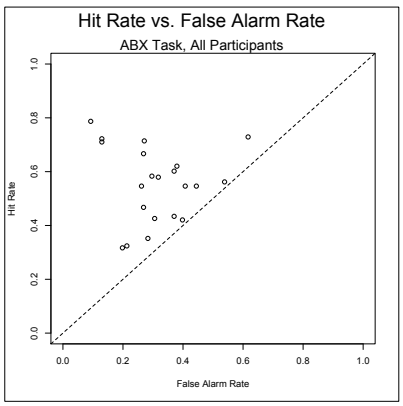

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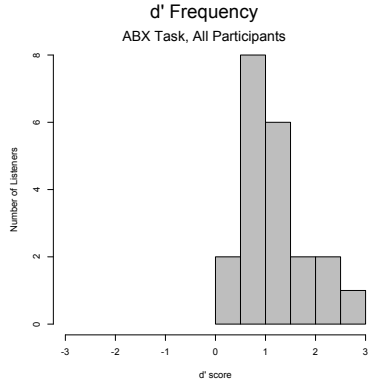

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ABX results

- **d′ is significantly different from 0 overall** (mean d′: 1.24, Wilcoxon test: V=231, p < 0.001)
- So, listeners said "X is like A" more often when X was actually like A than when X was actually like B
- BUT…

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ABX: Statistical vs. linguistic significance

- Listeners reported using cues like "the up and the down of each one" (intonation)
- Remember, X is literally the same as one of either A or B
  - Listeners were likely to have used any auditory differences between A and B, including intonation
  - Some of these cues may have nothing to do with an underlying voicing contrast

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Testing the "any auditory differences" strategy hypothesis

- AB task
  - Which one had a /d/—word A or word B?
- Speakers can't use the "any auditory differences" strategy, since there are only two sounds, and they are never the same
- (Forthcoming)

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So what?

- Speakers *might* be able to discriminate between flapped /d/ and /t/, but don't identify them—in ideal lab conditions, even in tokens taken from the minimal pair reading task
- These results generally support the findings of Herd et al. (2010) that listeners can't identify flapped /d/ and /t/
  - This holds even in relatively easy tasks, when frequency effects are mitigated, and bias is taken into account

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So what?

- Many speakers produce this distinction anyway, in both "wug" and minimal pair reading tasks (Braver 2010, 2011)
- Given the perception results, they probably do not do it for the benefit of hearers

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Conclusions

- American English speakers produce a small preceding vowel duration distinction between flapped /d/ and /t/
- The ID experiment suggests that listeners can't tell them apart, even in an ideal situation
- The ABX experiment showed moderate discriminability, but speakers reported using cues unrelated to the /d/-/t/ distinction
- Speakers don't maintain the distinction for the benefit of listeners, since they can't perceive it

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Thanks!

Thanks are due to Shigeto Kawahara, Bruce Tesar, Kristen Syrett, Peter Staroverov, Vandana Bajaj, the members of the Spring 2011 Rutgers phonetics seminar, and the audience of RULing VI for their comments and insights on this project.

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References

- Berko, Jean (1958). The Child's Learning of English Morphology. Word 14:150–177.
- Braver, Aaron (2010). *Incomplete Neutralization in American English Flapping*. Ms. Rutgers, The State University of New Jersey.
- Braver, Aaron (2011). *Incomplete Neutralization in American English Flapping: A Production Study*. In *Proceedings of the 34th Annual Penn Linguistics Colloquium*, volume 17 of *University of Pennsylvania Working Papers in Linguistics*. Penn Linguistics Club. http://repository.upenn.edu/pwpl/vol17/iss1/5/.
- Connine, Cynthia M.; Titone, Debra; and Wang, Jian (1993). Auditory Word Recognition: Extrinsic and Intrinsic Effects of Word Frequency. Journal of Experimental Psychology 19:81–94.
- Dinnsen, Daniel and Charles-Luce, Jan (1984). Phonological Neutraliza- tion, Phonetic Implementation and Individual Differences. Journal of Phonetics 12:49–60.
- Dmitrieva, Olga (2005). Incomplete Neutralization in Russian Final Devoicing: Acoustic Evidence from Native Speakers and Second Language Learners. Poster presented at the 149th Meeting of the Acoustical Society of America.

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References

- Fisher, William M. and Hirsh, Ira J. (1976). Intervocalic Flapping in English. In Papers from the Twelfth Regional Meeting of the Chicago Linguistic Society, pp. 183–198. Chicago Linguistic Society.
- 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.
- Gerrits, Ellen and Schouten, M.E.H. (2004). Categorical perception depends on the discrimination task. Perception and Psychophysics 66(3):363–376.
- Herd, Wendy; Jongman, Allard; and Sereno, Joan (2010). *An acoustic and perceptual analysis of /t/ and /d/ flaps in American English*. Journal of Phonetics 38:504–516.
- Huff, Charles T. (1980). Voicing and Flap Neutralization in New York City English. Research in Phonetics 1:233–256.
- Joos, Martin (1942). A Phonological Dilemma in Canadian English. Language 18(2):141–144.
- Macmillan, Neil A. and Creelman, C. Douglas (2005). *Detection Theory: A User's Guide*. Lawrence Erlbaum Associates Inc., Mahwah, NJ, 2nd edition.

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References

- Port, Robert (1976). The Influence of Speaking Tempo on the Duration of Stressed Vowel and Medial Stop in English Trochee Words. Doctoral Dissertation, University of Connecticut.
- Port, Robert and O'Dell, Michael (1985). *Neutralization and Syllable-Final Voicing in German*. Journal of Phonetics 13:455–471.
- Slowiaczek, Louisa M. and Dinnsen, Daniel (1985). On the Neutralizing Status of Polish Word-Final Devoicing. Journal of Phonetics 13:325–341.
- Slowiaczek, Louisa M. and Szymanska, Helena (1989). Perception of Word-Final Devoicing in Polish. Journal of Phonetics 17:205–212.
- Warner, Natasha; Good, Erin; Jongman, Allard; and Sereno, Joan (2006). Orthographic vs. Morphological Incomplete Neutralization Effects. Journal of Phonetics 34(2):285–293.
- Warner, Natasha; Jongman, Allard; Sereno, Joan; and Kemps, Rach`el (2004). Incomplete Neutralization and other Sub-Phonemic Durational Differ- ences in Production and Perception: Evidence from Dutch. Journal of Phonetics 32:251–276.
- Zue, Victor W. and Laferriere, Martha (1979). Acoustic Study of Medial /t, d/ in American English. Journal of the Acoustical Society of America 66:1039–1050.

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