An Ultrasound Investigation of Covert Articulation in Rapid Speech

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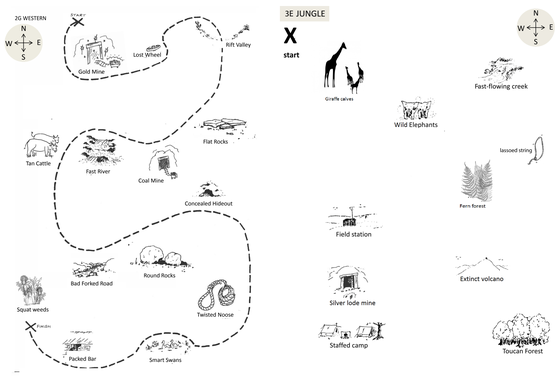
Coronal Stop Deletion

Word-final /t, d/ deletion in English has been described as a categorical phenomenon with **variable** application, conditioned by morpho-/phonological context, dialect and register/style, lexical factors, and speech speed. We argue that it is **gradient**: the amount of deletion has variable levels within it. We hypothesize that some instances of apparent deletion may be due to:

1. **temporal masking**, where the following articulation masks the alveolar articulation (e.g., "perfect memory"), or
2. **articulatory undershoot**, where the tongue tip does not reach the palate.

Map Task

Four subject pairs (total 8; 3F) did a cooperative speech task designed to elicit natural speech.



- Subject given a map with route traced between landmarks (target phrases), guides partner from start to finish, with simultaneous ultrasound imaging and audio recording
- 4 maps + reading task for style comparison
- Target phrases designed for comparison of phonologically probable deletion contexts to controls (e.g., "fast river" vs. "flat rocks" vs. "glass river")

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Ultrasound and Audio

- SonixTablet, by Ultrasonix
- Non-invasive method of imaging tongue, with probe stabilization
- 50fps with real-time hardware audio sync

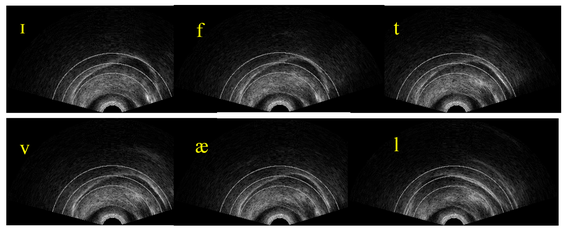


Figure 1: Frames from [ɪftvæl] of target "rift valley"

- Analysis of ultrasound frames from target phrases' acoustic onset to offset
- Palate trace used to draw 3 lines across each frame at alveolar ridge and 1, 2cm below; frame with peak constriction rated for magnitude: 0 (no movement), 1-2 (some movement), or 3 (complete constriction)
- Constriction rated for timing: before or after acoustic word boundary

(Ultrasound videos accompany this poster!)

Deletion Rates

When calculated by lack of closure (auditory), much lower than most previous literature:

	S107	S108	S109	S110
Map Task	0.28	0.16	0.17	0.12
Reading Task	0.00	0.17	0.12	0.07

When calculated by no audible release (cf. socio lit):

Map Task	0.60	0.50	0.48	0.22
Reading Task	0.25	0.46	0.41	0.17

Results

H1: Due to temporal masking, apparent /t, d/ deletion may be due to alveolar articulations occuring after the acoustic word boundary. **H1 not supported:**

	S107	S108	S109	S110
/t, d/ detected	0.00	0.03	0.04	0.00
/t, d/ deleted	0.00	0.00	0.00	0.00

Table 1: % "after" rating of ultrasound frames shows constriction rarely occured after the acoustic word boundary.

H2: Apparent /t, d/ deletion may be due to articulatory undershoot, in which case constriction ratings (height of tongue tip/blade relative to palate trace lines) should have variability. **H2 supported:**

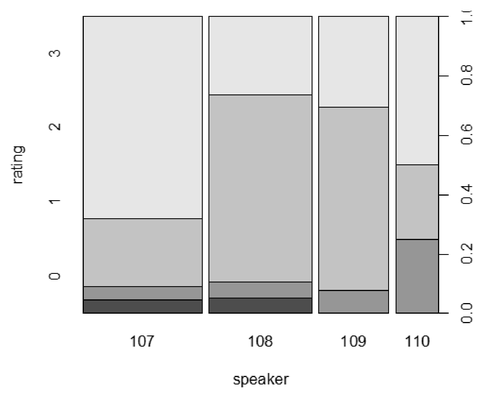
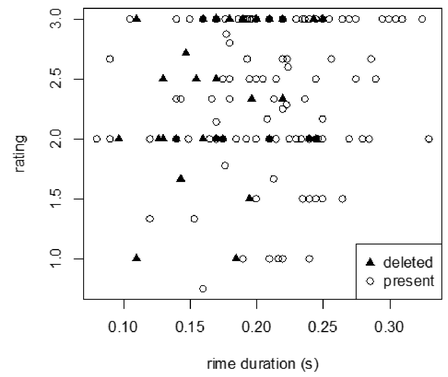
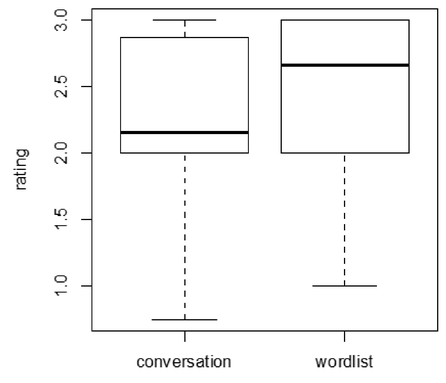


Figure 2: Magnitude ratings <3, indicating less than complete constriction, occurred between 30-75% of the time across subjects.

When /t, d/ is realized, speech rate has no significant effect, but when reduced, speed is a factor (β=5.36, t=2.22, p=0.0028)



Reading task resulted in higher constriction ratings than map task (β=0.26, t=2.73, p=0.0071)



Conclusion

There was no evidence of **temporal masking** on perceived deletion, but there was evidence of **articulatory undershoot**, with lower constriction magnitude in faster speech and higher constriction magnitude in reading style speech. Discrepancy in deletion rates by calculation (presence of closure vs. release) and when compared to previous literature indicates that **coding methodology** is a factor.

References

[1] Ruaridh Purse and Alice Turk. t/d deletion: Articulatory gradience in variable phonology. Poster presented at LabPhon 15 (2016).

[2] Anderson, Anne H. et. al. The HCRC Map Task Corpus. *Language and Speech*, 34(4):351–366, 1991.

[3] Catherine P. Browman and Louis Goldstein. Tiers in articulatory phonology, with some implications for casual speech. *Papers in Laboratory Phonology I: Between the grammar and physics of speech*, pages 341–376, 1990.

Planned Future Analysis

- Target phrases within deletion context triplets
- Non-target words such as direction words ("left", "west")
- Influence of pragmatic focus, stress, and socio factors, e.g., identity construction