The degree and time course of nasal coarticulation across communicative contexts: A study of the LUCID corpus

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1. Background

- Speakers adaptively modify their speech in response to the communicative situation along a continuum between **hypospeech** and **hyperspeech** (H&H theory [1]; Adaptive Speaker Framework [2]).
- **Coarticulation** (the overlap between articulatory gestures) is **suppressed in hyperarticulated clear speech** [1, 3].
  - Empirical evidence from CV coarticulation [4, 5, 6]
- In contrast, American English speakers *increased* **nasal coarticulation** *and* expanded vowel space in VN sequences when talking to a listener [7].

2. Research Questions

Q1: How do speakers vary the degree of nasal coarticulation when:

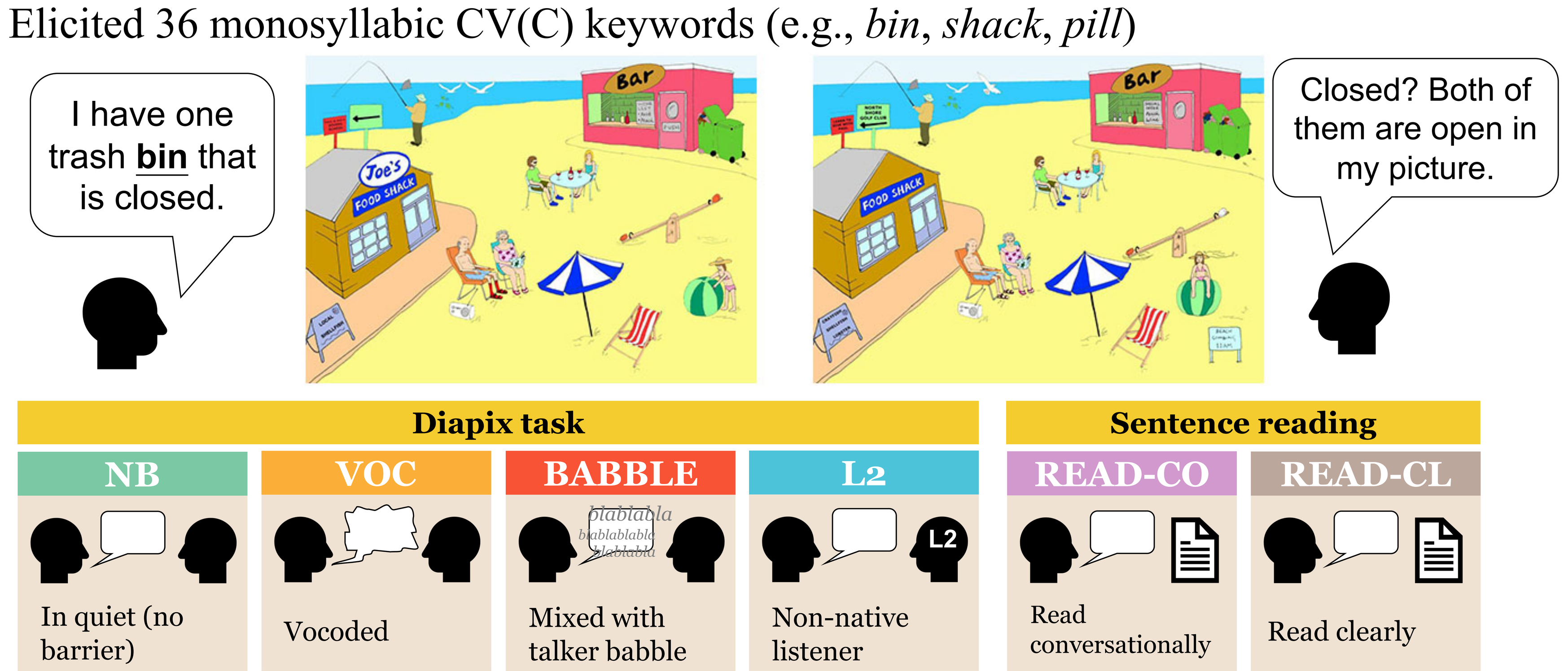
1. **conversing with a listener in communicatively challenging conditions** (e.g., speech to the listener is masked by background noise)?
2. **reading aloud to an imagined listener with perceptual difficulty** (e.g., one who is hearing-impaired)?

Q2: How does the **time course** of nasalization during the vowel in VN sequences vary across different communicative contexts?

3. Methods

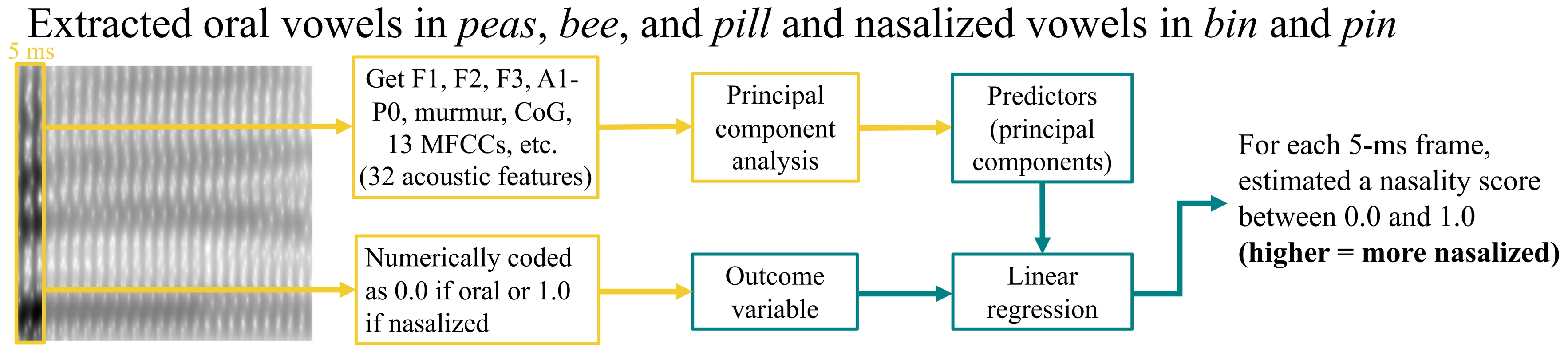
Speech data

- The LUCID corpus [8]
- 40 Southern British English speakers:
  - 1) completing interactive Diapix tasks in four communicative conditions (NB, VOC, BABBLE, L2);
  - 2) reading sentences in two speaking styles (READ-CO, READ-CL)
- Elicited 36 monosyllabic CV(C) keywords (e.g., *bin*, *shack*, *pill*)



Nasalization analysis

- Full Nasality from Acoustic Features (full NAF) [9]
- Extracted oral vowels in *peas*, *bee*, and *pill* and nasalized vowels in *bin* and *pin*

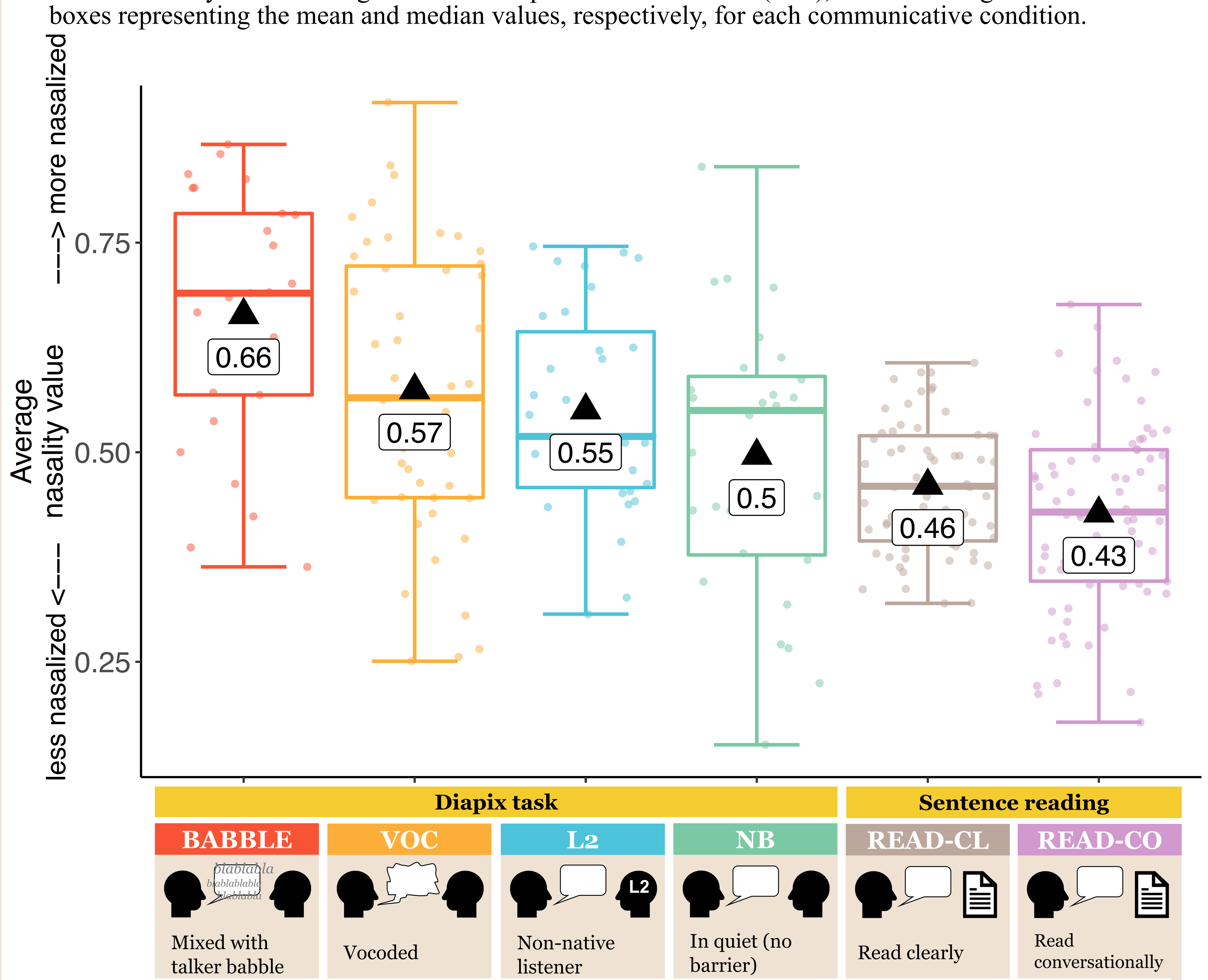


- Fitted a separate regression model for each speaker

4. Results

- Communicative conditions were compared for:
  - 1. **Nasality scores averaged across time points** using a Bayesian hierarchical regression model [10]: nasality ~ condition + repetition + (1 + condition | speaker)
  - 2. **Time-normalized nasality score curves** using a generalized additive mixed model [11]: nasality ~ condition + repetition + s(norm_time, by=condition) + s(norm_time, speaker, by=condition, bs="fs", m=1)

FIG 1. Nasality scores averaged across time points for each token (dots), with the triangles and lines in the boxes representing the mean and median values, respectively, for each communicative condition.



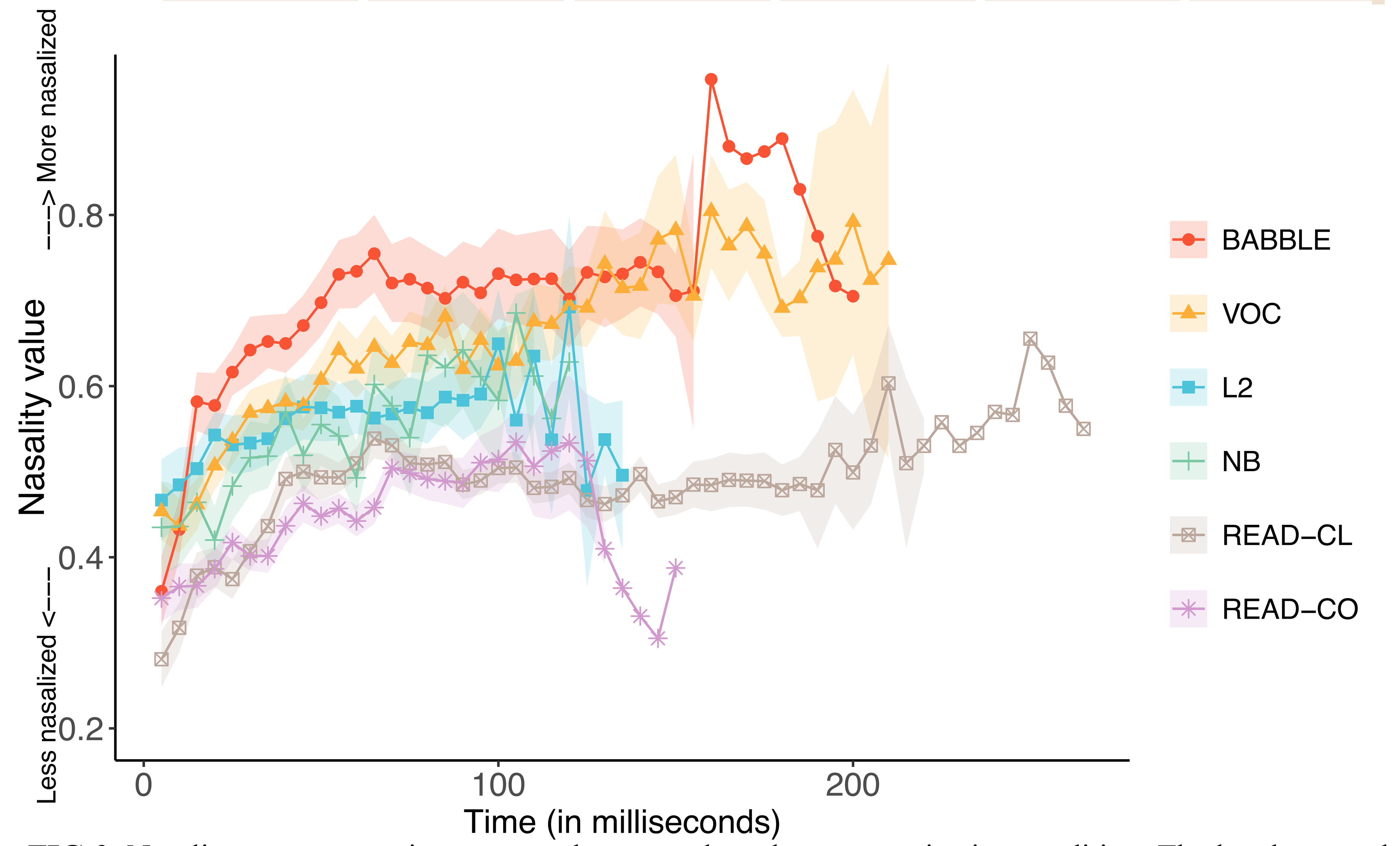
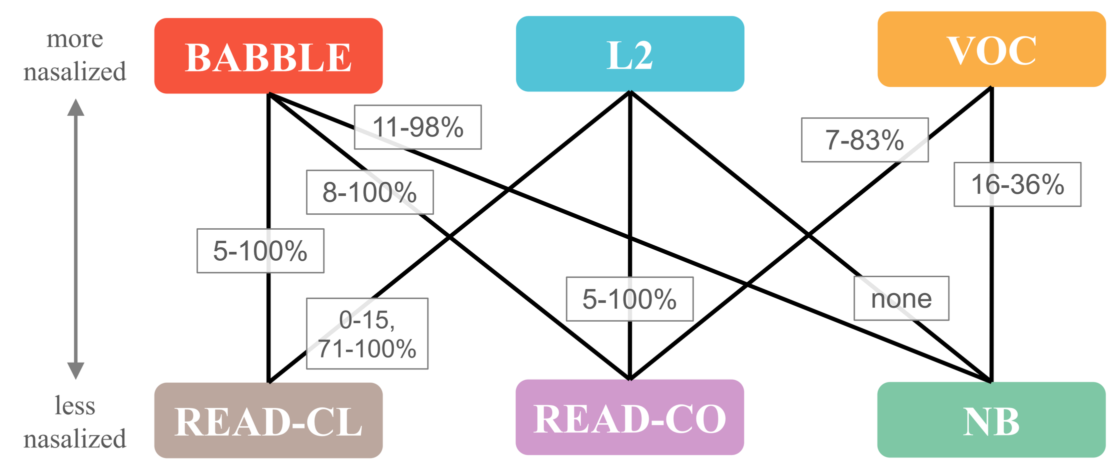


FIG 2. Nasality scores over time averaged across tokens by communicative condition. The bands around the curves indicate the 95% confidence intervals.

FIG 3. Hasse diagram summarizing significant differences in average nasality score and nasality curve. Each line indicates that the condition on the top had a significantly higher average nasality score than the condition at the bottom. The label over each line indicates when (in % time into the vowel) the time-normalized nasality curves of the two conditions differed significantly.



5. Discussion

- Speakers **increased nasal coarticulation** in response to real (BABBLE, VOC, L2) but not imagined (READ-CL) communicative barriers.
  - Even though they hyperarticulated (as evidenced by larger vowel space) in the presence of both real and imagined barriers [12].
- Increasing nasal coarticulation along with hyperarticulation seems to be unique to the real listener-directed speech.
  - Contrary to findings on coarticulation for other types of syllables [4, 6] and the view of coarticulation as a low-cost motor behavior [1].
- Difference in nasal coarticulation between conditions began soon after vowel onset (between 0% and 16% into the vowel).
  - The increase was not time-locked to the part of the vowel near the nasal coda (cf. prosodically induced changes in nasal coarticulation [13]).
- Results extended those of Scarborough and Zellou [7] to Southern British English and other types of realistic communicative contexts.
- Future research:
  - Examine why nasal coarticulation behaves differently from other syllable types in hyper-articulated listener-oriented clear speeches.
  - Explore how greater nasal coarticulation contributes to perceptual processes (e.g., speech segmentation).

Acknowledgements

We would like to thank Dr. Christopher Carignan for sharing analysis scripts of the Nasality from Acoustic Features method. The presentation of the current research is supported by a Graduate Research Fellowship from UT Austin's Program in British, Irish and Empire Studies to the first author.

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