Respiratory and supralaryngeal effects on speech breathing noise across loudness conditions and speaking tasks

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Introduction

Previous study [1] of respiratory kinematics & acoustics of speech breath:

Respiratory slope during inhalation correlated with intensity and F1 of breath noise.
Hypothesized: Steeper inhalation slope corresponded with greater mouth aperture.

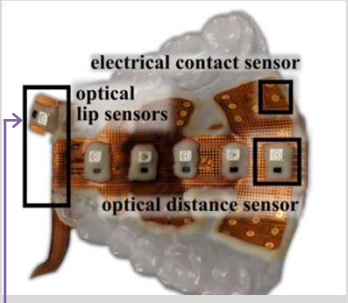
Current work:

Assess both **breath kinematics** and **oral aperture** and compare with acoustics of breath noise
Expand types of **speaking tasks**, following [2]
Include **loudness manipulation** (normal, loud)

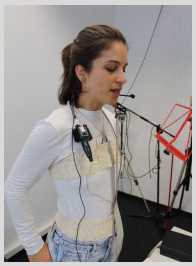
Research questions

RQ1: Do loudness and speech task affect a) acoustic intensity and/or b) F1 of breath noise and speech?
RQ2: Do loudness and speech tasks affect breathing slope?
RQ3: Does loudness affect lip opening?
RQ4: How do acoustic parameters relate to articulation: a) respiratory, b) lip aperture?

Methodology



Electro-optical stomotography
Optical distance sensors along with contact sensors. Here, just assess lip aperture.



Louder speech: Interlocutor wore headphones; no headphones for normal loudness. Normal preceded Loud.

3 Tasks: (random order)

1) **Reading** utterances beginning with *Ich mag* [bilabial]_[alveolar] (*Mate, Paten, Buesum,...*)
2) Monologue about a **Holiday**
3) Interactive turn-taking **Game** *Ich packe meinen Koffer*: Participants name items to pack in the suitcase until one person forgets an item in the list

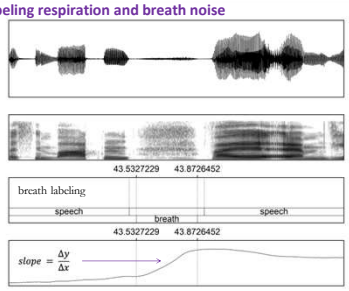
Head-mounted mic: Average intensity over whole breath, F1 over central third of breath (Burg algorithm, 5 formants, max. formant = 5.5 kHz, window length = 25 ms, dynamic range = 50 Hz)

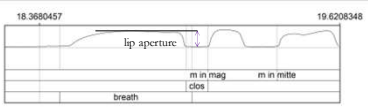
Respiratory kinematics: summed signal [4]: (thorax * 2) + abdomen

EOS (lip aperture): Synch issues with acoustics, only reading data with two bilabial closures at beginning of sentence

8 female speakers (EOS palate), Standard German; 21–34 y.o.

Labeling respiration and breath noise

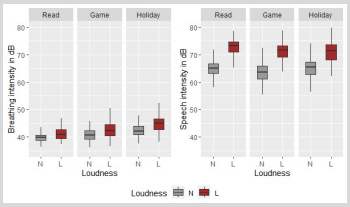




Labeling lip aperture

Results

RQ1a: Intensity, Loudness, Task



Speech breathing:
±Loud:
trend (t=2.17)
Task:
Game>Reading (t=2.51*)
Holiday>Reading (t=8.252***)

Speech:
±Loud:
(t=7.205***, 7.3dB difference)
Task:
No effect

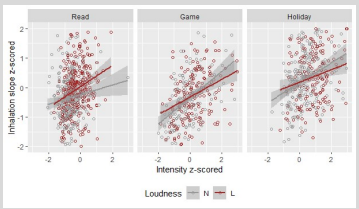
RQ1b: F1, Loudness, Task

±Loud:
trend (t=2.16)
Task: trends
Game≥Reading (t=2.07)
Holiday≥Reading: (t=2.001)

RQ2: Breathing slope, Loudness, Task

±Loud:
trend (t=2.14)
Task:
Holiday>Reading (t=2.96*)

RQ3: Lip opening, Loudness [Reading only]
±Loud:
More open lips in breathing for loud speech (t=3.77**)

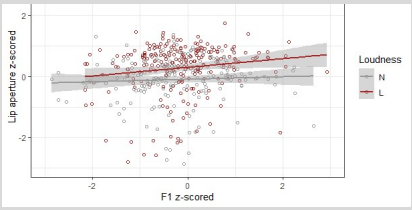


RQ4a: Acoustics (Intensity, F1) and respiration

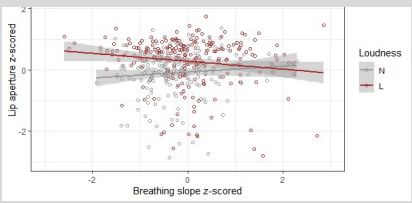
Strong effect of breathing slope on breath noise intensity (*t*=6.20***)

F1 (similar model): No effect

RQ4b: Acoustics and lip aperture
No effect.



Lip aperture and Respiration:
Contra hypothesis [1]: No effect



Discussion and future work

- Some breath F1 values may also reflect nasal coupling; values varied widely. Future work could separate perceived oral and nasal breath regions.
- Additionally, F1 is not always very prominent in breath noise, so may not be well-tracked by our algorithm.
- Tasks matter. Breathing for reading may show less variation than in other tasks (esp. with same sentence length).
- Here, lip data were only analyzed for reading. Synchronization problems made it difficult to label tasks with less predictable phonetic content.
- The reliability of the EOS distance signals should be explored further.

References:

[1] Werner, R., Fuchs, S., Trouvain, J., & Möbius, B. (2021). Inhalations in speech: Acoustic and physiological characteristics. *Proceedings of Interspeech 2021*.
[2] Lester, R. A., & Hoit, J. D. (2014). Nasal and oral inspiration during natural speech breathing. *Journal of Speech, Language, and Hearing Research, 57*(3), 734-742.
[3] Stone, S., & Birkholz, P. (2020). Articulation-to-speech using electro-optical stomatography and articulatory synthesis. *Proceedings of the 12th International Seminar on Speech Production*.
[4] Banzett, R. B., Mahan, S. T., Garner, D. M., Brughera, A., and Loring, S. H. (1995). A simple and reliable method to calibrate respiratory magnetometers and Respitrace. *Journal ofApplied Physiolology, 79*, 2169–2176.