Neck-surface Accelerometry in Voice and Swallowing Research

Victoria S. McKenna[1], Ph.D., CCC-SLP, Ann M. Alvar[1], B.S., Matías Zañartu[2], Ph.D.,
Georgia A. Malandraki[1,3], Ph.D., CCC-SLP, & Jessica E. Huber[1], Ph.D., CCC-SLP

[1]Department of Speech, Language, and Hearing Sciences, Purdue University
[2]Department of Electronic Engineering, Universidad Técnica Federico Santa María
[3]Weldon School of Biomedical Engineering, Purdue University

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Neck-Surface Accelerometers

Dimensions and Specifications

- Knowles BU-21771-000
- 1-axis sensor, with a Y-sensing axis
- 7.92 x 5.59 x 4.14mm
- Frequency response of 20Hz to 10 kHz
- Flat dB response up to approximately 3 kHz

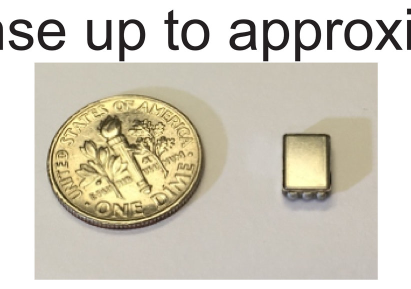


Fig 1. A Knowles accelerometer compared to a dime.

Assembly

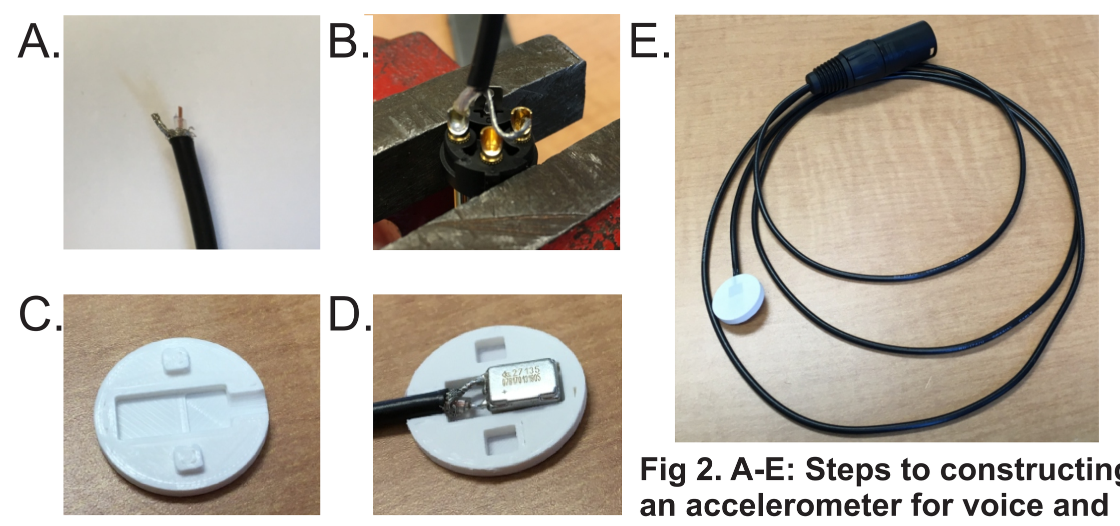


Fig 2. A-E: Steps to constructing an accelerometer for voice and swallowing measures.

Placement and Measurement

- The accelerometer is placed superior to the sternal notch and inferior to the cricoid cartilage (**Fig. 3**)
- The accelerometer captures vibration of the skin during voice and swallowing

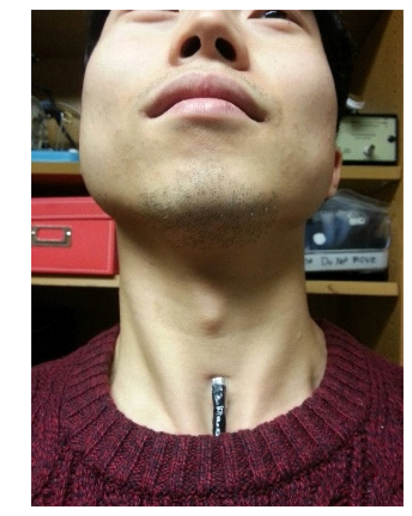


Fig 3. Example of accelerometer placement on the skin of the anterior neck.

Voice Research

- To produce voice, air must travel through the vocal folds to assist in their vibration to make sound, referred to as ***glottal airflow***
- Often, a pneumotachographic mask (**Fig. 4**) measures glottal airflow, but this is unatural and affects the quality of acoustic recordings
- **Accelerometers are a way to non-obstructively measure voice parameters**

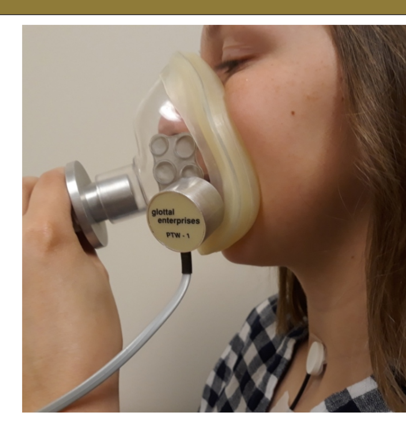


Fig 4. Pneumotachographic mask with neck-surface accelerometer for glottal flow calibration.

Methods

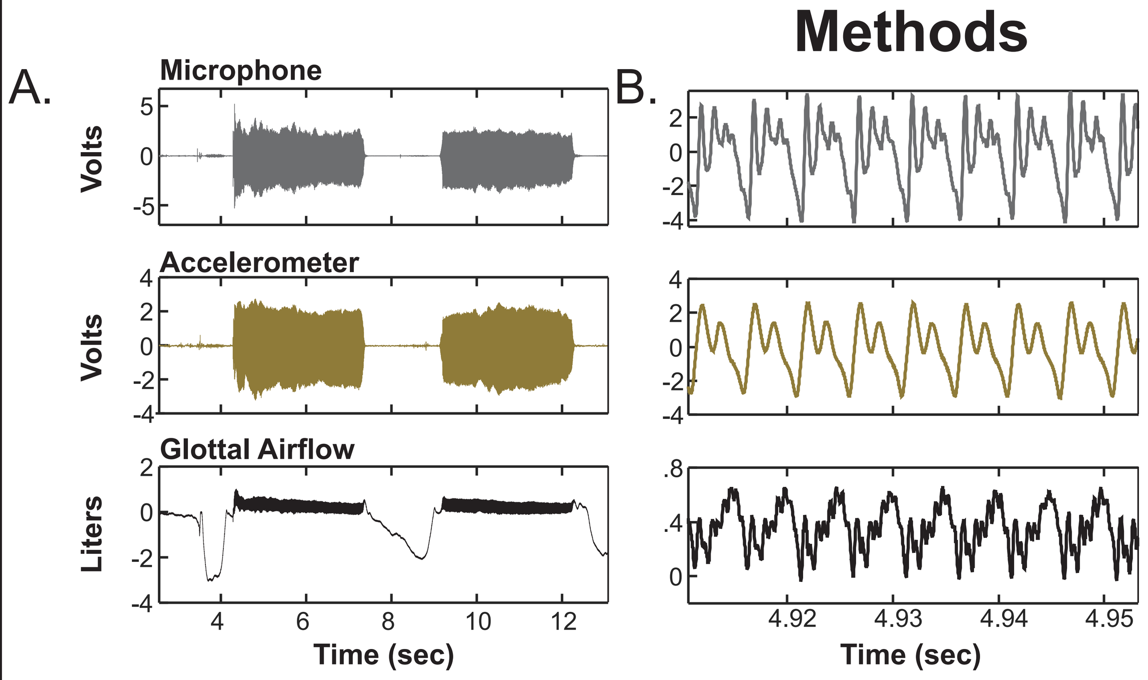
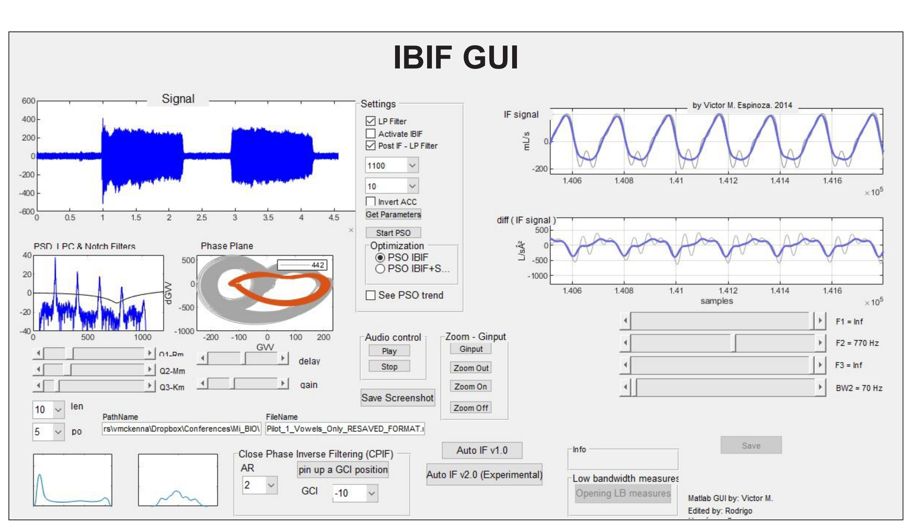


Fig 5. A. Microphone, accelerometer, and glottal flow signals during sustained vowels. B: The same vowel productions but zoomed-in to see individual cycles of each signal.

- Participants complete various speech tasks while wearing the mask and accelerometer in order to calibrate the accelerometer to a known airflow
- All data are acquired at 40kHz using AD Instruments PowerLab

- A customized impedance-based inverse filtering (IBIF) program calibrates the accelerometer signal to the glottal airflow [1,2]
- The IBIF program determines individualized airflow parameters
- Following calibration, the participant can speak freely without the mask and glottal flow parameters can be obtained from the accelerometer alone

Fig 6. IBIF graphical user interface (GUI). The MATLAB program determines person-specific parameters to calibrate the accelerometerto the glottal flow signal.



Swallowing Research

- Swallowing requires coordinating the oropharyngeal structures, larynx, esophagus, and respiratory muscles
- Little is known about how respiration, swallowing, and speech patterns are coordinated during typical meals
- **Accelerometer signals assist in identifying the timing when coordinated with speech and breathing**

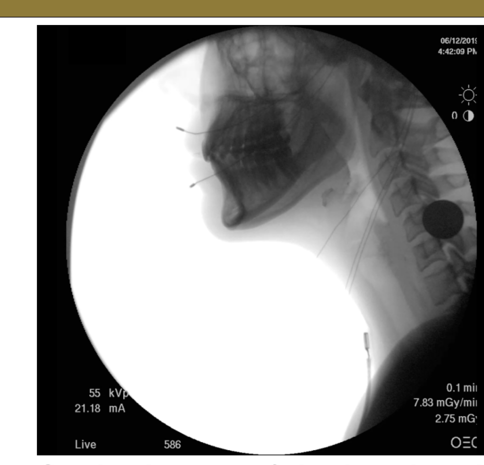


Fig 7. Sagittal x-ray of the head and neck. The accelerometer is seen sitting inferior to the larynx on the anterior neck.

Methods

- We are examining the aerodigestive system using videofluroscopy, respiratory plethysmography, accelerometry, and acoustics
- Accelerometer data are pre-amplified, then digitized at 2 kHz via a data acquisition board and recorded in MATLAB
- Participants complete conversational tasks that include monologues and answering questions while drinking sips of liquid

Fig 8. Videofluoroscopy of a single sip of barium.

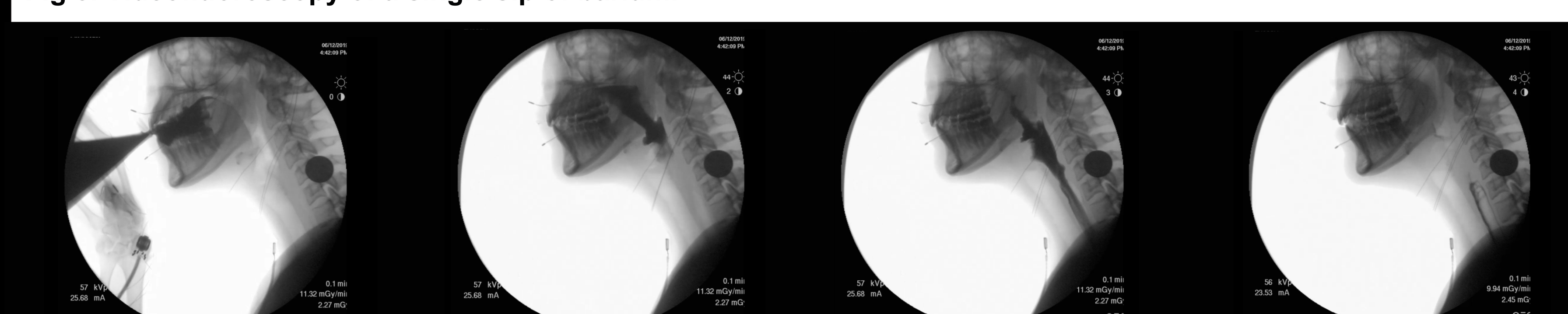


Fig 9. Respiratory and accelerometer signals from a single sip of barium. A 1st order low pass Butterworth filter was applied to the accelerometer signal. The swallow is identified from the upward deflection of the filtered signal.

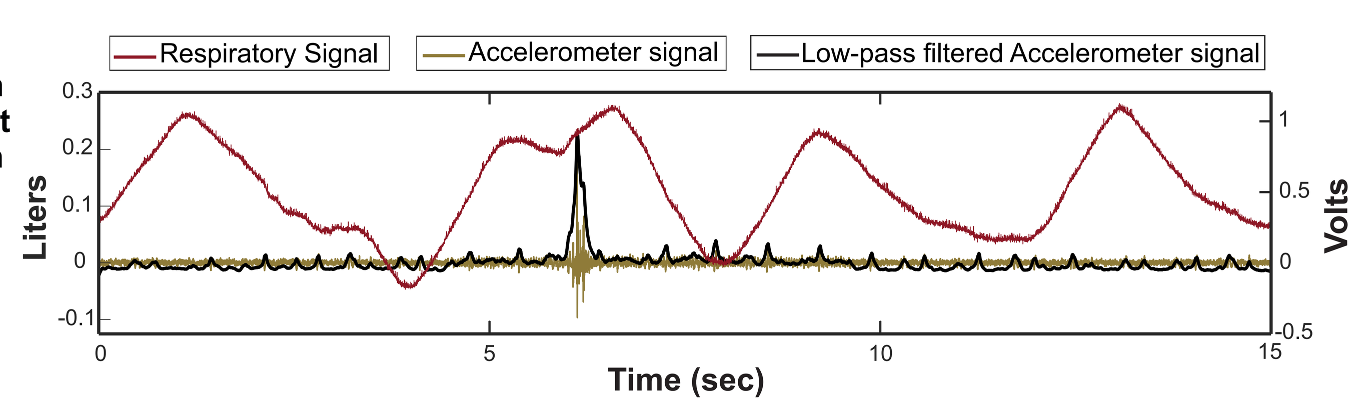
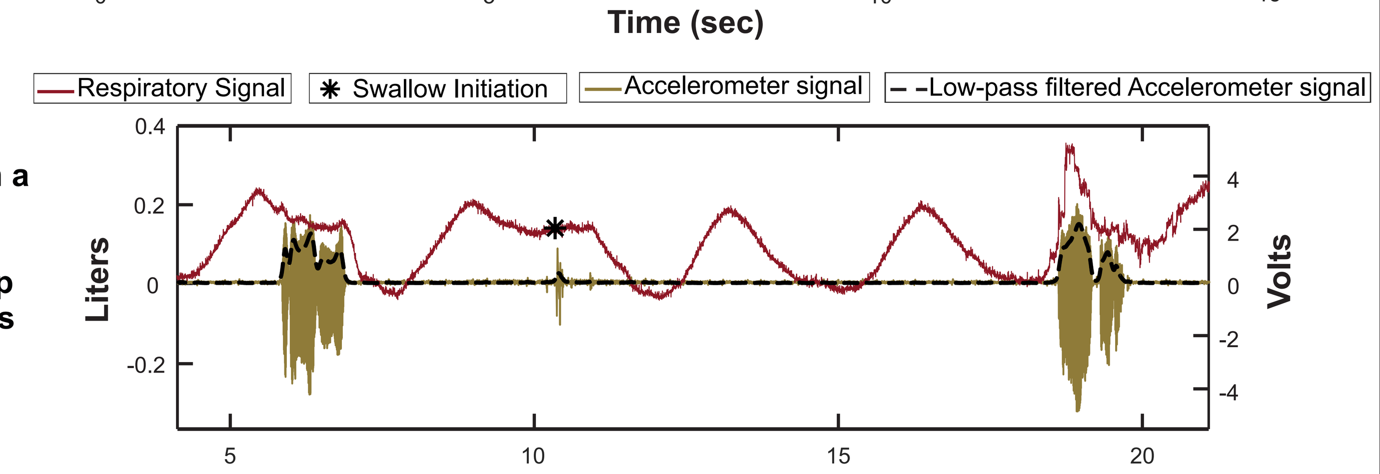


Fig 10. Respiratory and accelerometer signals from a conversational call-and response story. The participant talks, takes a sip of liquid, and then responds to the story. The swallow is identified from the accelerometer and noted here as an asterisk.



Future Directions

Impact

- Neck-surface accelerometers allow for non-invasive and non-obstructive speech and swallow measures
- Wearable technology allows researchers to measure data in natural settings and tasks

Future Work

- Developing algorithms to identify and process swallowing data from the sensor alone
- Examining patient populations at risk for voice and swallowing disorders

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