Neck-surface Accelerometry in Voice and Swallowing Research
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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 4.14 mm
- Frequency response of 20 Hz to 10 kHz
- Flat dB response up to approximately 3 kHz

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 unnatural and affects the quality of acoustic recordings.
- Accelerometers are a way to non-obstructively measure voice parameters.

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.

Methods

- 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 40 kHz using AD Instruments PowerLab.

Assembly

Fig 1. A Knowles accelerometer compared to a dime.

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

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

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

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.

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.

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References

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.

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

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

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.

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Fig 11. Respiratory and accelerometer signals with neck-surface accelerometer for glottal flow calibration.