Subject: Evaluation of Smartphone Apps as Sound Level Meters

Date: January 17, 2025

The papers of Kardous and Shaw (2014) and Kardous and Shaw (2016) describe the experimental design and results for unweighted and A-weighted sound level measurements for selected iOS and Android smartphones using internal microphones and external microphones, respectively. This summary is based on these two papers. Kardous and Shaw (2015) and Faber (2017) report the results of these two studies.

Evaluation Criteria and Methods

Kardous and Shaw (2014) examined 9 smartphones from the January 2013 market (4 iOS devices and 5 Android devices) with internal microphones using 10 apps. The follow up study of Kardous and Shaw (2016) used only the original 4 iOS devices and 4 of the 10 apps from the first study with two externally calibrated microphones.

Criteria

The iOS and Android apps were chosen based on this list of occupational noise criteria:

1. Report unweighted (C/Z/flat) and A-weighted sound levels.
2. 3 dB or 5 dB exchange rate (dosimeter level changes for exposure time changes).
3. Slow or fast response.
4. Equivalent continuous average sound level (Leq) or time-weight average.
5. Build-in microphone calibration adjustment using profiles.
6. Reporting and sharing features.

14 apps (10 iOS and 4 Android) were examined in Kardous and Shaw (2014). Only the original 4 iOS apps were examined in Kardous and Shaw (2016).

Methods

Randomized measurements were done using a split-split plot experimental design (experimental units: noise level - whole plot unit; device type - split-plot unit; app - split-split plot unit). The statistical power analysis required 6 replication blocks to achieve a power greater than 0.924 (Kardous and Shaw, 2014). Noise level was randomized in each block, device order was randomized with each noise level, and app order was randomized in each device. Differences in both unweighted (flat) and A-weighted sound levels measured in each test condition and the calibration reference was used to assess accuracy.

The tests done in Kardous and Shaw (2014, 2016) used 20 Hz to 20 kHz pink noise at 7 levels from 65 dB to 95 dB in 5 dB increments, which *reflected noise exposures in a typical workplace* (circa 2016).

Controlled measurements were done in a *diffuse sound field* to ensure the location (microphone direction) and size of each smartphone using an internal microphone (Kardous and Shaw, 2014) or an optional external microphone (Kardous and Shaw, 2016) did not affect the data collection; effectively normalizing this aspect of measurement. Kardous and Shaw (2014) notes in-field measurement conditions (i.e., temperature, humidity, stability and use-period of device) will influence measurements.

The reference measurement microphone and meter were calibrated between measurement sessions and annually at a National Institute of Standards and Technology (NIST) laboratory.

Conclusions

iOS devices and apps were found to be more accurate. In Kardous and Shaw (2014), the *SPLnFFT* app has the best agreement in unweighted SPLs, while the *SoundMeter* app had the best agreement in A-weighted SPLs. The iPhone 3GS with its internal microphone was used in both cases.

For the iOS devices, external microphones improved the accuracy and precision of noise measurements (Kardous and Shaw, 2016) for all 4 of the original iOS apps (*SPLnFFT*, *SoundMeter*, *SPL Pro*, and, *NoiSee*). *It is suggested that the internal microphone is the primary reason for poor accuracy and precision, not the app or smartphone hardware.*

The advantages and disadvantages of using smartphones as sound level meters are,

Advantages

- Sound level apps are readily and widely available and do not require specialized knowledge.
- Relative good accuracy and precision allowing for good initial measurements and evaluation.
- Improve awareness of workplace noise and advocate for the hearing health of workers.
- Improved accuracy by using an external microphone. Calibration profiles for external microphones are provided by some app developers.

Disadvantages

- Phone body shape will influence the microphone, particularly at high frequencies (Faber, 2017).
- The directionality of internal microphones is not known.
- Calibration of external microphones requires a calibrator and training.
- Cost of external calibrator might be prohibitive (Kardous and Shaw, 2016).
- Potential microphone coupling problems with the external calibrator (Kardous and Shaw, 2016).
- External microphone performance might change with time, handling, and measurement conditions.
- External microphones may not be factually comply with standards (Kardous and Shaw, 2016).
- As of 2016, no smartphone-based sound level measurement solution has met all the electrical and acoustical requirements of the American National Standards Institute (ANSI; 1983) and the International Electrotechnical Commission (IEC; 2013).

Decision

I have decided to purchase an XL2 sound level meter and a Class 2 microphone from NTI. This meter and microphone system has calibration certification and meets the IEC 61672 and ANSI S1.4 standards.

References

Faber, B. M. (2017). Acoustical measurements with smartphones: Possibilities and limitations. *Acoustics Today*, 13(2):10–17.

Kardous, C. A. and Shaw, P. B. (2014). Evaluation of smartphone sound measurement applications. *Journal of the Acoustical Society of America, Express Letters*, 135(4):EL186–EL192.

Kardous, C. A. and Shaw, P. B. (2015). Do sound meter apps measure noise levels accurately? *Sound and Vibration*, pages 10–13.

Kardous, C. A. and Shaw, P. B. (2016). Evaluation of smartphone sound measurement applications (apps) using external microhones - a follow-up study. *Journal of the Acoustical Society of America, Express Letters*, 140(4):EL327–EL333.