A COMPARISON OF wRECD AND RECD VALUES AND TEST-RETEST RELIABILITY

Paula Folkeard, AuD[1], John Pumford, AuD[2], Philipp Narten, BSc[1,3], Jonathan Vaisberg, PhD Student[1], Susan Scollie, PhD[1]

[1] National Centre for Audiology, Western University London (ON) Canada. [2]Audioscan, Dorchester (ON) Canada, [3] Lübeck University of Applied Sciences, Lübeck, Germany

PURPOSE

This study evaluated test-retest reliability and absolute agreement of the real ear to coupler difference (RECD) measured using the Audioscan Verifit (VF1) and the wideband real ear to coupler difference (wRECD) measured using the Audioscan Verifit 2 (VF2) in forty-two adult ears.

RECD:

The difference, in dB, between the SPL produced in the ear canal and the SPL produced in a HA-1 2cc-coupler by the same sound source (ANSI S3.46-2013). It is measured and used to account for individual ear canal acoustics. It is used to predict real ear aided responses from coupler responses and to convert HL audiometric data to ear canal SPL (Bagatto et. al, 2005).

Extended Bandwidth measurement:

As extended-bandwidth hearing aids become available, the need to measure the higher frequencies these aids produce has led to the need for wideband verification solutions. To facilitate extended high frequency measurement, Audioscan has adopted a 0.4cc coupler in order to measure in 1/3 octave bands up to 12.5 kHz. The wRECD is the difference in SPL produced in an occluded ear canal and in the 0.4cc coupler, and provides difference values up to 12.5 kHz. Exchange of RECD data between the Verifit and Verifit2 is enabled by software conversions of wRECD to an ANSI-standard RECD reporting format, which is referenced to the HA-1 coupler (ANSI S3.46-2013).

RECD Considerations:

(1) Changes in the positioning of the probe tube relative to the eardrum have a greater effect in the higher frequencies (Khanna & Stinson, 1985; Hellstrom & Axelsson, 1994). Therefore, we evaluated the test-retest of both RECDs across frequencies.

(2) RECD values differ based on the type of coupling to the ear (earmold vs. foam tip) (Moodie et al, 2016). Therefore, we measured the RECD and wRECD with both coupling types.

METHOD

Probe microphone measures were completed using the Audioscan VF1 and VF2 hearing instrument fitting systems. The probe microphones and coupler microphones of the VF1 and VF2 were calibrated prior to each participant. Coupler responses were measured daily. RECD and wRECD were completed for both fitting systems: The probe was placed in the ear canal within 5 mm of the eardrum. The ear was occluded with one coupling type (foam tip or custom earmold with venting plugged medially). The tubing was attached to the RECD transducer and the stimulus was measured until the measurement was stable, re-seating the tip or mold to resolve slit leaks and repositioning the probe tube if it was moved during placement of tip or mold. Once the measurement was completed, the tip or mold and the probe tube were removed from the ear. The procedure was repeated with the other ear. After measurements of both ears were completed, the procedure was repeated using the same coupling. The procedure was repeated again using the alternate coupling (tip or mold). Measurements were counterbalanced for ear and coupling.

RESULTS

Test-Retest within each system (Figure 1)

The first and second measures within each system were compared using repeated measures ANOVA with retest and frequency as repeated factors. Separate ANOVAs were completed for foam tip and earmold data, and for RECD and wRECD measurements at 1/3 octave band frequencies to 8000 Hz. Results revealed **no significant effect of retest** for earmold RECDs on the VF2 ($F(2.57, 92.6)=0.871$, $p=0.433$, $\eta^2=0.021$) and the VF1 ($F(2.51, 103)=0.270$, $p=0.812$, $\eta^2=0.007$). Similarly, foam tip RECDs did not differ between test and retest on the VF2 ($F(3.35, 137.4)=0.216$, $p=0.903$, $\eta^2=0.005$) or on the VF1 ($F(2.94,120.6)=1.08$, $p=0.361$, $\eta^2=0.026$.

RESULTS CONTINUED

RECD to wRECD comparisons (Figure 2)

Repeated measures ANOVAs were completed with RECD type as a within-subjects factor (VF1-RECD, VF2-wRECD), at 17 repeated frequencies at 1/3 octave bands (200-8000 Hz), on the averaged RECDs from test and retest. Post-hoc comparisons were used with Bonferroni correction to locate the frequencies at which measures differed between measurement types. Frequencies at which measures differed significantly are marked in Figure 2 with asterisks (*) if the differences were significant and exceeded 3 dB.

- **Earmold RECD-wRECD data:** Results indicated a significant frequency by system interaction ($F(2.73, 112)=18.3$, $p<.001$, $\eta^2=0.31$). Post-hocs revealed small but significant differences 200 Hz to 3150 Hz, and at 5000 Hz. However, all values were less than 3 dB except for 200 Hz (3.1 dB) and are therefore within expected test-retest variation for real ear measurement (Jespersen & Møller, 2013).
- **Foam tip RECD-wRECD data:** Results indicated a significant frequency by system interaction ($F(3.0, 122.9)=24.1$, $p<.001$, $\eta^2=0.37$). Post-hocs revealed small but significant differences from 200-5000 Hz. However, all values were less than 3 dB except for 200 Hz (3.1 dB) and 250 Hz (3.1 dB) are within expected test-retest variation, as was observed for earmold RECDs.

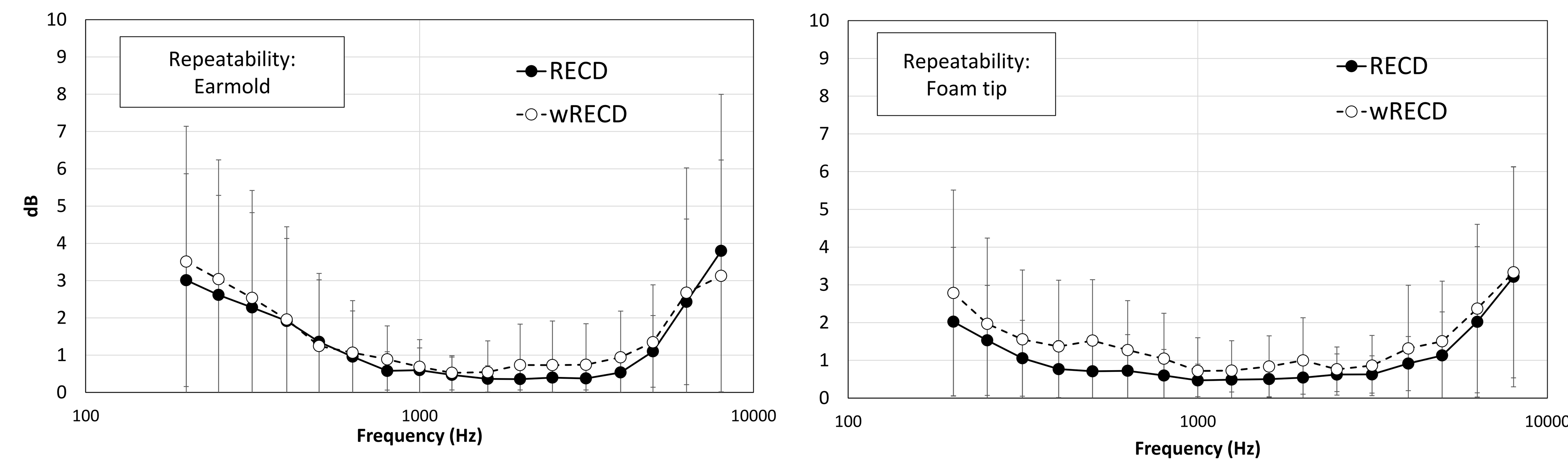

FIGURE 1. Mean test-retest differences between RECDs measured with earmolds (left) and foam tips (right) with the VF1 (RECD) and VF2 (wRECD). Error bars show one standard deviation.

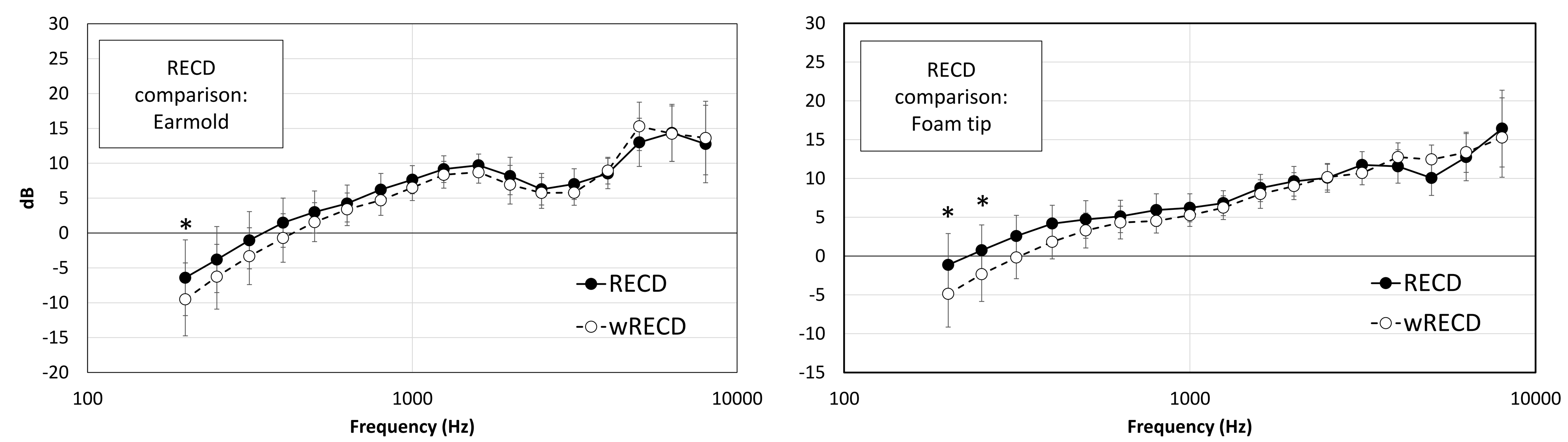

FIGURE 2. Mean RECDs measured with earmolds (left) and foam tips (right) with the VF1 (RECD) and VF2 (wRECD). Error bars show one standard deviation.

CONCLUSIONS & CLINICAL IMPACT

The new ANSI standard for real ear measurement provides a standardized reference coupler (HA-1) for the RECD. Test-retest reliability on the two systems was acceptable and equivalent. Exchange of RECD values between Verifit and Verifit2 was also evaluated, and provide HA-1-referenced values that are within 3 dB of one another, with most frequencies agreeing to within less than 1 dB on average. The main advantage of the wRECD is that it supports measurement in the extended high frequency range. Coupler volume transforms allow conversion between RECD and wRECD formats. This supports threshold conversion and simulated real-ear measurements in the extended high frequency band, and allows reporting of RECDs and wRECDs in a standard format.

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Western National Centre for Audiology

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