The Effect of Probe Level on Wideband Energy Reflectance Measurements of the Contralateral Acoustic Stapedius Reflex Threshold

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ABSTRACT

Recent studies have suggested that wideband energy reflectance (ER) measurements of the acoustic stapedius reflex threshold (ASRT) provide more sensitive estimates of reflex threshold than traditional methods. The present study examined the effect of probe level on the contralateral ASRT for the simultaneous presentation of the activator and probe using a wideband ER system. ASRTs for a 1000 Hz activator tone were estimated in 19 young adults with normal hearing. A repeated-measures design was used in obtaining ASRTs for three wideband-chirp levels of 65, 60 and 55 dB SPL, as well as for a standard 226-Hz probe tone. The experimental ASR threshold was determined by examining shifts in ER across the frequencies 250 to 2000 Hz using the combination of two statistical tests. A magnitude test used an F-ratio to compare baseline variance with that induced by the activator. A correlation test examined the shape of the ER shift across frequency for different activator levels. A repeated measures ANOVA revealed that there was a significant effect of ASR threshold method. Post hoc analyses revealed that there was no significant difference in ASRT between the 65- and 60-dB-probe conditions, however the 55-dB-probe condition resulted in higher ASRTs than the other two by 11.6 and 6.6 dB, respectively. ASRTs obtained using the experimental ER method were significantly lower than those obtained with the clinical system by as much as 22 dB for the 65-dB-probe condition. These results suggest an interaction between the wideband probe level and the contralateral ASRT for simultaneous presentation of the activator and probe. The nature of this interaction is likely reflex facilitation for higher probe levels.

INTRODUCTION

Several studies have demonstrated the utility of wideband acoustic transfer functions including power or energy reflectance (ER) for estimating acoustic stapedius reflex thresholds (ASRTs) (Feeney & Keefe, 2001; Feeney, Keefe, & Marryott, 2003; Feeney, Keefe & Sanford, 2004; Schairer, Ellison, Fitzpatrick & Keefe, 2006). Feeney et al. (2003) measured contralateral ASRTs using 1000 and 2000 Hz activator tones. The probe stimulus was a series of wideband 40 ms chirps presented simultaneously with the activator. They reported that contralateral ASRTs for adults were as much as 12 dB lower than those obtained with standard clinical methods using a 226 Hz probe tone. Feeney, Keefe and Sanford (2004) measured the ipsilateral ASRT using a filtered click (200 – 2000 Hz) as the wideband probe stimulus with a simultaneous 4000 Hz activator stimulus. Wideband estimates of the ASRT were only 3 dB lower than those obtained with a clinical system. One possible explanation for the disparity in these findings is that the simultaneous presentation of the contralateral wideband chirp used in Feeney et al. 2003 facilitated the ASR.

The purpose of the present study was to examine the effect of the wideband probe level on contralateral ASRTs using the same system employed by Feeney et al. 2003.

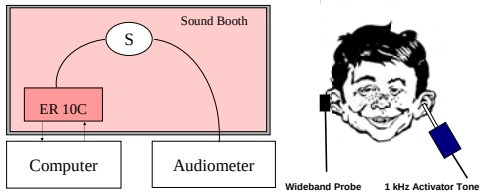
METHOD

PARTICIPANTS

19 young adults with normal hearing (9 m, 10 f)

INSTRUMENTATION

1. Clinical impedance system (GSI-33) for admittance screening and measurement of clinical ASRT
2. Audiometer: Madsen 622
   a. Hearing assessment of subjects
   b. 1000 Hz activator stimulus
3. Reflectance system based on (Keefe et al, 1992)
   a. Personal computer
   b. A/D and D/A card
   c. ER-10C microphone system
   d. Custom software (Keefe et al.,1992)
   e. ER Probe signal is wideband chirp (250-8000 Hz)



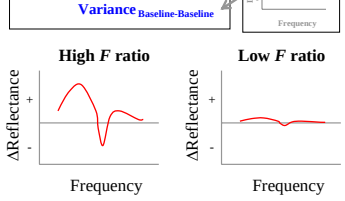
PROCEDURE

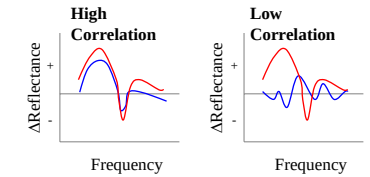
1. The contralateral ASRT for a 1000 Hz tone was obtained for each subject using a GSI-33 clinical admittance system with a 226 Hz probe tone and a Madsen 622 audiometer for the presentation of the activator signal.
2. Contralateral ASRTs for the 1000 Hz tone were then obtained using wideband ER after the technique developed by Feeney and Keefe (2001).
   a. The overall level of the wideband chirp was 65, 60 or 55 dB SPL. The presentation order of the probe condition was randomized across subjects.
   b. The step size of the activator was 4 dB and varied over a range of 40 dB from 4 dB above to 36 dB below the clinical reflex threshold. Two experimental runs were conducted for each subject in each condition.
3. The difference between baseline and activator responses was obtained to determine the change in ER induced by the reflex (Fig 1).
4. A **Magnitude** and **Correlation** method were used to calculate the acoustic reflex threshold (Feeney & Keefe, 2001).

REPEATED MEASURES EXPERIMENTAL DESIGN

ER Probe Level	1 kHz Contralateral ASR	ER ASRT Estimate
• 65 dB SPL	Run 1 (11 activator levels), Run 2 (11 activator levels)	Lowest ASRT
• 60 dB SPL	Run 1 (11 activator levels), Run 2 (11 activator levels)	Lowest ASRT
• 55 dB SPL	Run 1 (11 activator levels), Run 2 (11 activator levels)	Lowest ASRT

$$F = \frac{\text{Variance}_{\text{Activator-Baseline}}}{\text{Variance}_{\text{Baseline-Baseline}}}$$





The numerator of the *F*-ratio for each activator condition was the variance derived from the activator-baseline difference for a given activator level across the 37 1/12 octave frequency bins from 250 to 2000 Hz for the change in reflectance for each activator condition. The ASR was judged as present if the *F*-ratio was significant for an alpha level of 0.05 in a 2-tailed statistical test.

For the correlation statistical test, the shift in energy reflectance across frequency from 250 to 2000 Hz for an activator-baseline difference was cross-correlated with the shift measured for the next higher activator level using the Fisher's *Z* transformation to approximate a normal distribution (Kleinbaum, Kupper, and Muller, 1988).

RESULTS

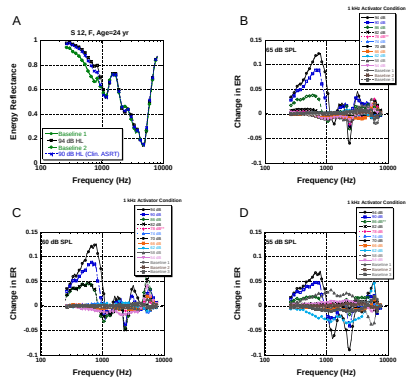


Figure 1. Data for S 12: Panel A shows ER for 65 dB probe condition for highest two 1000 Hz activator levels. Panels B, C and D show change in ER as function of activator level for the 3 probe conditions, 65, 60 and 55 dB SPL, respectively.

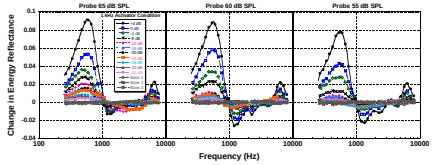


Figure 2. Mean contralateral ASR ER responses for the 1000 Hz activator for the 3 probe levels for each of the 11 activator conditions for the 19 participants.

There was a significant effect of reflex method (Clinical, Probe 65, Probe 60 & Probe 55), F(3,18)= 40.9, p<.001. Mean ASRTs for the 19 Ss are plotted in Figure 3 for each reflex method. Table 1 shows the results of mean comparisons using the Bonferroni adjustment for multiple comparisons. The mean ASRT for the 65 dB probe condition was not significantly different from the 60 dB probe condition, but all other comparisons were significantly different.

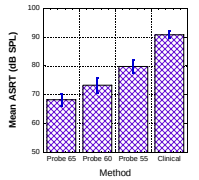


Figure 3. Mean ASRT as a function of method. Error bars represent ±1 SE.

Table 1. Post-hoc analyses of mean differences for each ASRT condition. The Bonferroni test was used to adjust for multiple comparisons.

Method (I)	Method (J)	Mean Difference (I-J)	Std. Error	Sig.(a)
1 Probe 65	2	-5.1	2.5	0.361
	3	-11.6(*)	2.1	<.001
	4	-22.5(*)	2.2	<.001
2 Probe 60	1	5.1	2.5	0.361
	3	-6.6(*)	1.7	0.008
	4	-17.5(*)	2.3	<.001
3 Probe 55	1	11.6(*)	2.1	<.001
	2	6.6(*)	1.7	0.008
	4	-10.9(*)	2.0	<.001
4 Clinical	1	22.5(*)	2.2	<.001
	2	17.5(*)	2.3	<.001
	3	10.9(*)	2.0	<.001

* The mean difference is significant at the .05 level.
a Adjustment for multiple comparisons: Bonferroni.

DISCUSSION

The significant effect of wideband probe level on the ASRT suggests a reflex facilitation effect. A similar but smaller effect (2.5 dB) was recently reported for the 226 Hz probe level in a contralateral reflex test (Day & Feeney, submitted). This is also similar to the facilitation effect reported by Terkildesn et al. (1970) for ASR growth functions. The large reduction in ASRT with the wideband method may be explained in part by this facilitation effect. Non-simultaneous presentation of the activator and probe may eliminate the facilitative nature of the wideband probe. This has been suggested by the results of Feeney, Keefe and Sanford (2004) who used a spectral separation of the probe and activator and by Schairer et al. (2006) who used a temporal separation of the probe and activator. The latter method holds the greatest promise for facilitating ASRT measurement with a wideband probe, as there is no restriction on activator or probe bandwidth.

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