Stapedial Reflex and Ears With High Static Acoustic Admittance

Jeffrey J. DiGiovanni
Ohio University, Athens

Dennis T. Ries
University of North Texas, Denton

Purpose: To evaluate modified acoustic reflex diagnostic protocols for a group of individuals (*n* = 9) with high peak compensated static acoustic admittance (Y_{tm}) tympanograms.

Method: A modified procedure designed to improve acoustic stapedius reflex threshold (ASRT) measurements in individuals with high-admittance tympanograms was employed in both an experimental and a control group. ASRTs were measured at 0.5, 1.0, and 2.0 kHz, ipsilateral and contralateral. Measurements were obtained within each condition for 7 ear canal pressures that were set to 0, ±50, ±100, and ±150 daPa (relative to tympanometric peak pressure [TPP]).

Results: Though measuring ASRTs at −50 daPa (relative to TPP) in the high-admittance and normal groups did not result in significantly better thresholds than at TPP, the absent reflex rate was reduced when the ear canal pressure was changed by −50 daPa during ASRT measurements.

Conclusions: Based on this sample, it is suggested that a patient presenting with high peak compensated static acoustic admittance (peak $Y_{tm} \geq 2.1$ mmho) undergo ASRT evaluation with the ear canal pressure set to −50 daPa (relative to TPP).

Key Words: acoustic reflex, immittance, stapedial reflex, high admittance

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A tympanic membrane presenting higher than normal admittance (lower impedance) may render acoustic stapedius reflex thresholds (ASRTs) immeasurable (Hall & Ghoreyab, 1991). This high-admittance condition can be due to an absence of the fibrous double layer of the tympanic membrane resulting in a monomeric (atrophic) area (Sadé, 1993). Typically, this condition does not affect hearing sensitivity. The net tympanometric outcome is a higher than normal peak compensated static acoustic admittance (peak Y_{tm}) value as well as a potential disruption of acoustic stapedius reflex (ASR) measures (Haapaniemi, Suonpää, Salmivalli, & Tuominen, 1994). This situation can preclude clinicians from obtaining useful information about the status of the middle ear and those portions of the central nervous system within the ASR arc.

ASR evaluations routinely are performed at the tympanometric peak pressure (TPP) because this produces the greatest admittance at the tympanic membrane (Hall & Mueller, 1997; Martin & Coombes, 1974; Rizzo & Greenberg, 1979; Terkildsen & Thomsen, 1959). This technique allows measurement of admittance changes due to the stapedial muscle action to be assessed at the point of greatest admittance, thereby allowing detection of relatively small changes in the amount of energy passing into the middle ear. This pressure value may not be the most reliable for ASR measurement in persons with a high peak Y_{tm} tympanogram, however, as they may exhibit greater than normal variability in their reflex tracings. This exaggerated variability can result from the relatively large changes in admittance that occurs around the peak with even slight changes in ear canal pressure. For example, when the probe device is in the ear, it is plausible that small head or jaw movements can cause the probe to shift slightly over time, thus causing small fluctuations in ear canal pressure. Alternatively, greater variability can result from a greater transmission of biological noise to the microphone near the tympanometric peak.

ASRTs may still be evident in some persons with high peak Y_{tm} tympanograms by employing higher activator levels for the eliciting stimulus. This would produce a stronger reflexive response leading to greater changes in admittance (Wilson & McBride, 1978). The ASRT would then be detectable provided the change in admittance was sufficient to overcome the increased variability imposed by the high peak Y_{tm} tympanogram.

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The stronger response overcoming the increased variability would effectively require a higher criterion (e.g., 0.03 or 0.04 mmhos). The disadvantage of this procedure is that the activator level required to elicit the ASR would often exceed safe levels (≤115 dB SPL; Hunter, Ries, Schlauch, Levine, & Ward, 1999).

There is, however, some evidence that ear canal pressures slightly above or below the TPP can provide some advantage in measuring ASR in instances where there is a high peak Y_{tm} (DiGiovanni & Schlauch, 2000). Similarly, Rizzo and Greenberg (1979) showed that the ASRT did not increase until the ear canal pressure was shifted by more than ±80 daPa. These findings suggest that altering the ear canal pressure used when measuring ASRTs may enhance the possibility that a clinician will obtain a repeatable and consistent outcome.

The present study investigated the measurement of ASRT levels in persons with high-admittance tympanograms as a function of ear canal pressure to establish whether decreasing tympanic membrane admittance allows for detection of the reflexive response at lower sound levels. This is based upon the fact that increases in the positive or negative air pressure in the ear canal produce lower admittance at the plane of the tympanic membrane (Terkildsen & Thomsen, 1959). Lowering tympanic membrane admittance by this method is expected to reduce variability in the measured ASR response by transferring the point of measurement to a tympanometric region with a shallower slope. It is hypothesized that ear canal pressure values other than the TPP, but that differ by no more than 80 daPa in either direction, result in better ASRT measures in persons with high peak Y_{tm} tympanograms. In addition, greater changes in pressure relative to TPP will produce an excessive decrease in admittance that is more difficult for the stapedial contraction (ipsilateral or contralateral) to overcome resulting in elevated ASRTs.

Method

Participants

Nine adult participants with high-admittance tympanograms were recruited based on a review of clinic charts at the University of North Texas Speech and Hearing Center (Denton) and the Ohio University Therapy Associates (Athens), as well as from new patients seen at both facilities. The average age of this group was 37.1 years (range = 20–75 years; 6 women, 3 men). In addition, a group of 10 adults with normal tympanometric findings were recruited from the Ohio University student population to serve as a control group. The average age of this group was 20.3 years (range = 18–23 years; 10 women). Data were collected from one ear per participant. Data were collected on the ear with the higher Y_{tm} in the experimental group serving as the probe ear, and the ear was selected randomly for the control group. An admittance criterion of 2.1 mmho was applied to separate normal from high-admittance tympanograms (Holte, 1996) for purposes of recruitment and measurement. This liberal cutoff value is well beyond the 90th percentile (1.46 mmho) for normal (Margolis & Heller, 1987) and was selected to provide a high likelihood that all of the participants in the high-admittance group truly exhibited Y_{tm} values that fell outside of the normal range. That is, if the peak Y_{tm} was equal to or greater than 2.1 mmho, the tympanogram was categorized as having a high peak Y_{tm}. The average admittance was 3.1 mmho (range = 2.1–5.3) and 0.6 mmho (range = 0.3–1.0) for the high-admittance and control groups, respectively. Persons with conductive hearing loss (air–bone gap > 10 dB at any octave frequency from 0.25 to 6.0 kHz) were excluded from participation, as even a slight conductive loss can preclude ASR measurement (Jerger, Anthony, Jerger, & Mauldin, 1974).

Audiometric data were reported from each participant's most recent clinical audiogram, provided the results were obtained within a year of the date he or she participated in the experiment; otherwise, a new audiogram was established. An audiogram was deemed valid if the measures occurred within the past 12 months and were performed by a certified and licensed audiologist. Group averages and ranges of audiometric thresholds for the relevant frequencies are shown in Table 1. The average differences across groups never exceeded 9 dB, and audiometric thresholds were less than 50 dB HL at 0.5, 1.0, and 2.0 kHz. This minimized the possibility of absent reflexes or worse ASRTs due to the degree of hearing loss (Silman & Gelfand, 1981). Three of the 9 participants with high-admittance tympanograms had hearing loss. All of the control group participants had normal hearing sensitivity (thresholds < 15 dB HL at any of the audiometric frequencies tested).

Instrumentation

Admittance measurements (tympanometry and ASRTs) were obtained using a clinical admittance measuring device (Grason-Stadler Model GSI 33). The admittance measuring device was calibrated yearly to conform to American National Standards Institute (ANSI) calibration standards for immittance measurement devices (ANSI S3.39-1987). Calibration of the 226-Hz probe tone was verified before each measurement session using the cavities of known volumes of air (0.5, 2.0, and 5.0 cc) provided by the manufacturer. The ASR eliciting stimuli were 0.5-, 1.0-, and 2.0-kHz pure tones. For the 0.5-kHz and 1.0-kHz conditions, the stimulus duration was 62 ms with a 9-ms rise and fall time. In one presentation, the 62-ms pure tone was presented 12 times in succession with a silent period of 62 ms between each one. The 2.0-kHz conditions were identical to the 0.5- and 1.0-kHz conditions with the one difference where the duration of the silent period was 53 ms. These specifications are the standard outputs used by the Grason-Stadler hardware, which would be the same as used clinically, thereby maximizing clinical applicability.

Air- and bone-conduction thresholds were obtained using a diagnostic audiometer (Grason-Stadler Model GSI 61 or GSI 16) calibrated yearly to conform to ANSI standards for

Table 1. Average audiometric thresholds and ranges for both groups.

Group	500 Hz	1000 Hz	2000 Hz
Normal	5.5 (–5–10)	7.0 (0–10)	5 (0–10)
High-admittance	11.1 (–5–40)	13.9 (–5–45)	13.9 (0–45)

audiometers (ANSI S3.6-2004). Tones were output to earphones (Telephonics Model TDH-49) mounted on supra-aural cushions (Telephonics Model MX-51/AR) and a bone vibrator (Radioear Model B-71).

Procedure

All procedures were approved by the institutional review boards at the University of North Texas and Ohio University. The participants provided written informed consent before participating in the experiment. Otoscopic examinations were performed on all test ears. Pure-tone, air-, and bone-conduction thresholds were measured if needed.

Next, a tympanogram was measured on each test ear to estimate the TPP that served as the basis for the physical ear canal pressures evaluated during ASRT testing. Tympanograms were obtained using a positive-to-negative pressure sweep covering a range of +200 to −400 daPa at a pump speed of 400 daPa/s with a 226-Hz probe tone.

Finally, ASRT measures were performed on all participants at TPP, as determined from the tympanogram, and at three positive and three negative pressure values relative to the TPP. The positive and negative ear canal pressures used were ±50, 100, and 150 daPa (relative to TPP). Ipsilateral (probe and reflex activator in same ear) and contralateral (probe in high-admittance ear and reflex activator in opposite ear) ASRTs were obtained using activator-tone frequencies of 0.5, 1.0, and 2.0 kHz. Pulsed activator tones were used for both ipsilateral and contralateral ASRT measurements. ASRT evaluation began at least 10 dB below the ASRT, and the activator tone was increased in 5-dB steps until a response was obtained, at which point the level was reduced by 10 dB and the process repeated. A 5-dB step size was selected to mimic the step size employed in routine clinical evaluations. The ASRT was the first ascending level at which two of three reflex responses were obtained that produced an admittance change of ≥ 0.02 mmho. The ASRT was labeled as "no response" if three consecutive presentations at 115 dB SPL produced no quantifiable response (Hunter et al., 1999). A level of 120 dB SPL, 5 dB above the maximum safe output, was assigned to all of the "no response" results for purposes of mathematical calculation. The ASRTs were obtained in random order within the ipsilateral and contralateral conditions with respect to each ear canal pressure implemented at each frequency. The ipsilateral conditions were measured together, as were the contralateral conditions. Successive participants were alternated between "ipsilateral first" and "contralateral first."

Results

The TPP and peak Y_{tm} data for the high-admittance and control group participants are shown in Table 2. All participants in the control group had tympanograms with peak Y_{tm} ranging from 0.3 to 1.0 mmho with an average of 0.58 mmho. The participants in the high-admittance group had tympanograms with a peak Y_{tm} of 2.1 to 5.3 mmho with an average of 3.10 mmho.

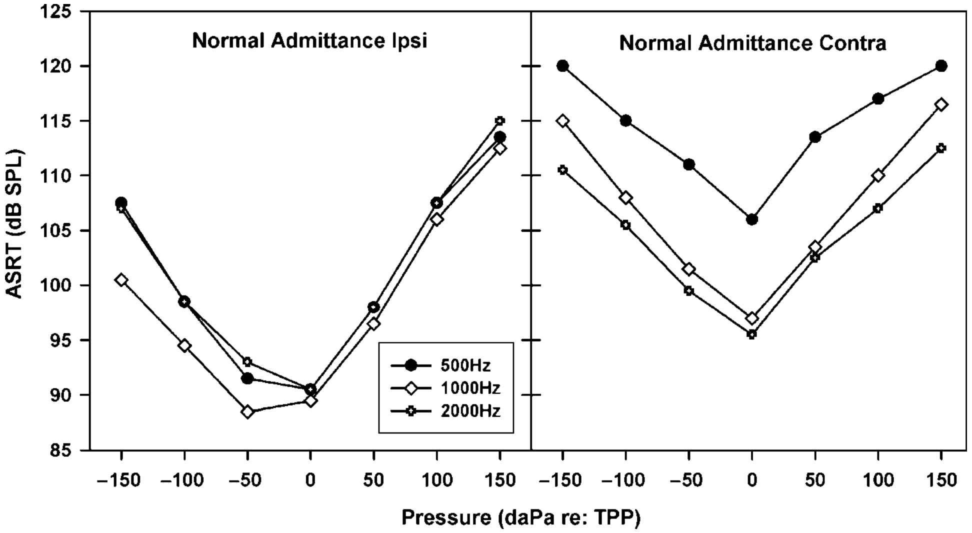
Figures 1 and 2 show ASRTs as a function of pressure for the ipsilateral and contralateral measures at 0.5, 1.0, and 2.0 kHz. The result obtained from the control group, shown in Figure 1, visually illustrates that the ASRT increases as the pressure is offset progressively from TPP. The only exception to this trend occurred for the 1.0-kHz ipsilateral condition where the ASRT improved by 1.0 dB for an ear canal pressure of –50 daPa (relative to TPP). The high-admittance group, however, consistently had the lowest average ASRTs at –50 daPa, as shown in Figure 2. Recall that in addition to a no response at 115 dB SPL being calculated as 120 dB SPL, there was a greater number of no responses at extreme pressures, especially for positive pressure. As a result, the slopes of the curves in Figures 1 and 2 at extreme pressures might be greater than if no numerical value was averaged.

Tables 3–6 show average ASRT results across participants for the high-admittance and control groups, respectively. ASRTs are reported in these tables for each activator tone frequency at the seven ear canal pressure values (TPP, ±50, ±100, and ±150 daPa) employed in the study. Tables 3 and 4 suggest that the high-admittance group had better average ASRTs at ear canal pressures offset from TPP by –50 daPa at 0.5, 1.0, and 2.0 kHz than at TPP both ipsilaterally and contralaterally. In fact, –50 daPa was the only pressure that showed a systematic decrease in ASRTs (relative to TPP) for the high-admittance group. The improvements ranged from 1.1 dB for the 2.0-kHz contralateral condition to 8.8 dB for the 0.5-kHz ipsilateral condition. This is contrary to the control group shown in Tables 5 and 6 who had higher ASRTs at

Table 2. Peak compensated static acoustic admittance (Y_{tm}) and tympanometric peak pressure (TPP) for each participant in the control and high-admittance groups.

Control group			High-admittance group		
Participant	TPP (daPa)	Peak Y_{tm} (mmho)	Participant	TPP (daPa)	Peak Y_{tm} (mmho)
N1	–10	0.6	S1	10	2.7
N2	5	0.5	S2	25	2.8
N3	30	0.5	S3	–20	2.5
N4	–15	0.6	S4	15	3.3
N5	–10	0.4	S5	5	3.0
N6	10	0.3	S6	5	2.1
N7	5	1.0	S7	20	3.3
N8	10	0.5	S8	10	2.9
N9	10	0.9	S9	–10	5.3
N10	5	0.5			

Figure 1. Acoustic stapedius reflex thresholds (ASRTs) for ipsilateral and contralateral stimulus conditions across different tympanic peak pressures (TPPs) and different activator tone frequencies for the control group.



–50 daPa (relative to TPP) than at TPP in five of the six frequency and ipsilateral/contralateral conditions.

Tables 5 and 6 suggest that the control group participants exhibited the best average ASRT at TPP, except for the 1.0-kHz ipsilateral condition where the threshold at –50 daPa (relative to TPP) was better by 1.0 dB. The ear canal pressure –50 daPa (relative to TPP) always produced the next best average ASRT, with the one exception at 1.0 kHz noted above.

To quantify the significance of the results, two-way analysis of variance (ANOVA) tests were performed on each condition set, namely the ipsilateral and contralateral conditions. For each ANOVA, the effects of pressure and frequency were tested. For the ipsilateral conditions, both the effects of pressure, $F(6, 150) = 27.36$, $p < .05$, and frequency, $F(2, 150) = 22.74$, $p < .05$, were significant for the normal group, while the effects of pressure, $F(6, 150) = 3.84$, $p < .05$, but not frequency, $F(2, 150) = 1.66$, $p = .19$, were significant in the high-admittance group. There was no Pressure × Frequency interaction for either group: normal group, $F(12, 150) = 0.30$, $p = .99$; high-admittance group, $F(12, 150) = 0.25$, $p = .99$. The contralateral conditions showed a similar pattern of results. Specifically, the effects of pressure—normal group, $F(6, 151) = 13.57$,

Figure 2. ASRTs for ipsilateral and contralateral stimulus conditions across different TPPs and different activator tone frequencies for the high-admittance group.

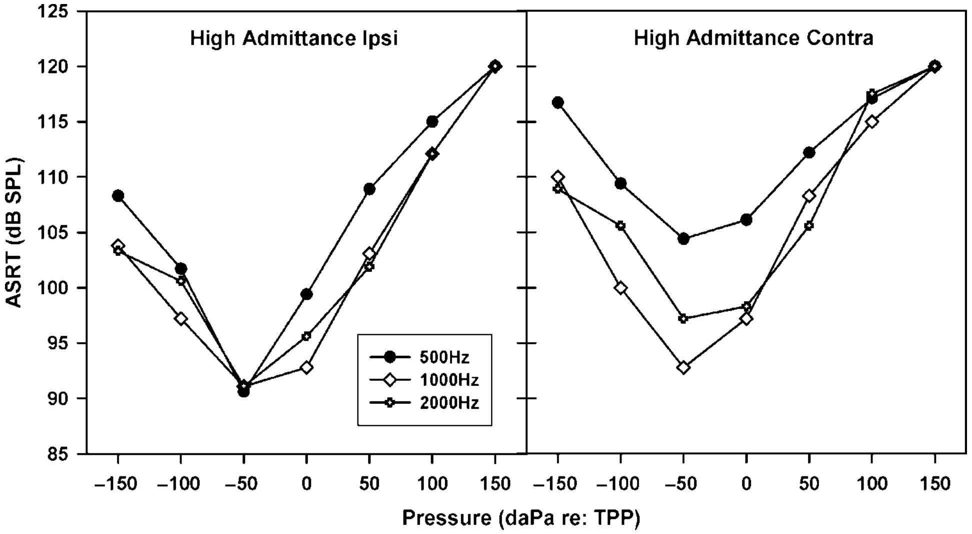


Table 3. Average ipsilateral acoustic stapedius reflex thresholds (ASRTs), standard deviations, and the absent ASRT rate measured at different ear canal pressures and different activator frequencies for the high-admittance group.

Pressure relative to TPP (daPa)	500 Hz ipsilateral			1 kHz ipsilateral			2 kHz ipsilateral		
	AVG (dB SPL)	*SD* (dB)	ABS (%)	AVG (dB SPL)	*SD* (dB)	ABS (%)	AVG (dB SPL)	*SD* (dB)	ABS (%)
–150	108.3	9.4	22	103.8	10.6	22	103.3	11.2	22
–100	101.7	11.2	22	97.2	9.7	0	100.6	12.9	22
–50	90.6	6.3	0	91.1	11.7	11	91.1	6.5	0
0	99.4	13.1	22	92.8	11.8	11	95.6	10.7	11
50	108.9	11.1	33	103.1	12.5	22	101.9	8.8	11
100	115.0	8.7	56	112.1	9.9	44	112.1	10.4	44
150	120.0	0.0	100	120.0	0.0	100	120.0	0.0	100

Note. AVG = average ipsilateral ASRTs; ABS = absent ASRT rate.

Table 4. Average contralateral ASRTs, standard deviations, and the absent ASRT rate measured at different ear canal pressures and different activator frequencies for the high-admittance group.

Pressure relative to TPP (daPa)	500 Hz contralateral			1 kHz contralateral			2 kHz contralateral		
	AVG (dB SPL)	*SD* (dB)	ABS (%)	AVG (dB SPL)	*SD* (dB)	ABS (%)	AVG (dB SPL)	*SD* (dB)	ABS (%)
–150	116.7	6.6	56	110.0	10.0	44	108.9	11.1	44
–100	109.4	10.4	22	100.0	10.0	11	105.6	14.5	44
–50	104.4	12.4	22	92.8	7.5	0	97.2	12.3	11
0	106.1	11.1	33	97.2	11.5	11	98.3	15.6	22
50	112.2	12.0	56	108.3	11.7	33	105.6	11.8	22
100	117.1	7.6	67	115.0	8.7	56	117.5	6.1	11
150	120.0	0	100	120.0	0.0	100	120.0	0.0	100

Table 5. Average ipsilateral ASRTs, standard deviations, and the absent ASRT rate measured at different ear canal pressures and different activator frequencies for the control group.

Pressure relative to TPP (daPa)	500 Hz ipsilateral			1 kHz ipsilateral			2 kHz ipsilateral		
	AVG (dB SPL)	*SD* (dB)	ABS (%)	AVG (dB SPL)	*SD* (dB)	ABS (%)	AVG (dB SPL)	*SD* (dB)	ABS (%)
–150	107.5	8.9	30	100.5	8.6	10	107.0	12.7	40
–100	98.5	4.7	0	94.5	3.4	0	98.5	9.4	10
–50	91.5	4.7	0	88.5	4.7	0	93.0	5.9	0
0	90.5	5.5	0	89.5	5.9	0	90.5	5.9	0
50	98.0	8.2	10	96.5	5.3	0	98.0	8.9	10
100	107.5	8.9	30	106.0	10.2	20	107.5	11.6	40
150	113.5	8.5	60	112.5	10.1	60	115.0	10.5	80

Table 6. Average contralateral ASRTs, standard deviations, and the absent ASRT rate measured at different ear canal pressures and different activator frequencies for the control group.

Pressure relative to TPP (daPa)	500 Hz contralateral			1 kHz contralateral			2 kHz contralateral		
	AVG (dB SPL)	*SD* (dB)	ABS (%)	AVG (dB SPL)	*SD* (dB)	ABS (%)	AVG (dB SPL)	*SD* (dB)	ABS (%)
–150	120.0	0	70	115.0	8.2	70	110.5	10.4	50
–100	115.0	8.2	50	108.0	8.6	30	105.5	10.4	30
–50	111.0	9.9	50	101.5	4.1	0	99.5	7.9	10
0	106.0	8.1	20	97.0	4.8	0	95.5	9.3	10
50	113.5	8.5	60	103.5	9.7	20	102.5	12.5	30
100	117.0	6.3	80	110.0	10.8	50	107.0	11.8	40
150	120.0	0	100	116.5	7.5	80	112.5	10.1	60

$p < .05$; high-admittance group, $F(6, 151) = 13.81$, $p < .05$—and frequency—normal group, $F(6, 151) = 24.19$, $p < .05$; high-admittance group, $F(6, 151) = 4.09$, $p < .05$—were significant for both groups, while there was no Pressure × Frequency interaction for either group: normal group, $F(12, 151) = 0.55$, $p = .88$; high-admittance group, $F(6, 151) = 0.38$, $p = .97$.

Post hoc assessments were performed to gauge the effect of frequency and pressure on ASRTs. The Tukey honestly significant difference was used for all post hoc comparisons. Frequency comparisons were made separately for the three activator tone frequencies used to obtain the ipsilateral and contralateral ASRTs for the normal and high-admittance groups. A few findings that will be discussed are as follows: (a) none of the ipsilateral ASRTs for the 500-, 1000-, or 2000-Hz comparisons were significantly different in the high-admittance group ($p = .14$, $p = .35$, and $p = .87$ for the 500/1000, 500/2000, and 1000/2000 comparisons, respectively); (b) the 500-Hz contralateral ASRTs obtained from the normal group were significantly different than those measured at 1000 Hz and 2000 Hz ($p < .05$), but the 1000-Hz ASRT did not differ significantly from that obtained using a 2000-Hz activator tone ($p = .06$); and (c) the high-admittance group's ASRTs obtained using a 500-Hz activator tone differed significantly from those obtained using a 1000-Hz tone ($p < .05$) but not from those measured using a 2000-Hz tone ($p = .06$).

A summary of the results for the post hoc comparisons assessing the significance between the ASRT measured at –50 daPa relative to TPP and the other pressures for each group's ipsilateral and contralateral conditions are provided in Table 7. From these analyses, the following notable observations will be discussed below for both groups: (a) the ASRTs at –50 daPa relative to TPP are not significantly different than those measured at TPP for either group or stimulus ear, (b) the normal group's ipsilateral ASRTs at –100 daPa relative to TPP are significantly worse than those measured at TPP, and (c) the ASRTs measured in the positive pressure conditions are significantly worse than those obtained at TPP except for +50 daPa relative to TPP in the high-admittance group's contralateral condition.

Discussion

The outcomes clearly indicate that there is a differential effect of shifted ear canal pressure on the ASRT. A small, negative ear canal pressure shift does not significantly affect the ASRT, whereas the equal and opposite positive ear canal pressure shift significantly increases the measured ASRT. In that regard, making positive pressure shifts should be avoided when attempting to obtain accurate ASRTs. Likewise, negative pressure shifts greater than –50 daPa relative to TPP produce significant increases in the ipsilateral ASRTs in both groups. As a result, pressure shifts greater than –100 daPa relative to TPP should be avoided when attempting to measure accurate ASRTs. It is clear from the present data set and analyses that a –50-daPa pressure shift relative to TPP has little detrimental effect upon the ASRT.

The results support the use of a protocol that includes measurement of ASRTs at negative ear canal pressures relative to the TPP in persons with high peak Y_{tm} tympanograms. This method allows for acquisition of ipsilateral ASRTs at similar sound pressure levels while allowing the possibility of a lower absent rate in this population. In fact, the absent ASR rate decreased from 14.7% to 3.7% on average, across frequency for the ipsilateral condition and from 22% to 11% for the contralateral condition. This mild pressure decrease lowers the absent ASR rate while not affecting the threshold unduly. Overall, these findings support utilization of slightly negative pressure in the ear canal to improve the performance of ASRT measures in individuals with high-admittance tympanograms who have a peak Y_{tm} greater than 2.1 mmho. In addition, these findings agree with our observation that the ASR waveform varied less with a mild, negative ear canal pressure. The high-admittance ASRTs were generally variable with or without the stimulus presentation. However, as the ear canal pressure was changed positively or negatively, the variability in admittance was reduced. While no significant improvement in ASRT was measured at –50 daPa relative to TPP pressure, there is a trend in that direction that is readily apparent for those with high-admittance tympanograms, even provided the relatively modest size of the groups in this study. It remains unclear, however, as to the mechanism that produced the significant increase in the ASRTs measured at all positive pressures.

The ASRTs from the control group agree with previous studies. Our findings show that for pressures at and beyond –100 and +50 daPa (relative to TPP) the ASRT was significantly increased for the control group. Rizzo and Greenberg (1979) showed significant threshold increases for pressures at and beyond ±80 daPa. These findings are in agreement, as any difference between the studies in the actual pressure found, beyond which a significant threshold increase is measured, is likely a result of the actual pressures at which measurements were made. One departure from this is for the 500-Hz

Table 7. Post hoc results comparing each pressure against 0 daPa relative to TPP for the two groups separately for the grouped ipsilateral and contralateral conditions.

		Pressure relative to TPP (daPa)						
Group	Condition	–150	–100	–50	0	50	100	150
Normal	Ipsilateral	**<.05**	**<.05**	.99	—	**<.05**	**<.05**	**<.05**
Normal	Contralateral	**<.05**	**<.05**	.09	—	**<.05**	**<.05**	**<.05**
High-admittance	Ipsilateral	**<.05**	.84	.50	—	**<.05**	**<.05**	**<.05**
High-admittance	Contralateral	**<.05**	.83	.96	—	.14	**<.05**	**<.05**

Note. Significant differences are in boldface.

ipsilateral condition for the high-admittance group. It appears that higher ASRTs were obtained in this condition than the other two frequencies and all the contralateral conditions. It appears likely that low-frequency energy absorption by the middle ear produced this effect, which would be greatest for the 500-Hz activator tone in the ipsilateral conditions in this study (Finkelstein, Zohar, Talmi, Rubel, & Shanny, 1992; Kringlebotn, 2000).

When measuring the ASRT, a balance needs to be achieved between stability (the inverse of variability) of the baseline and the efficiency of energy transfer. In cases of normal tympanic membranes, the stability is sufficient to justify measuring the ASRT at the point of maximum efficiency of energy transfer (i.e., TPP). However, when the tympanic membrane has nonpathological anomalies that lead to a high peak Y_{tm}, the stability of the system is decreased at TPP. This results in an increase in the activator tone level needed to obtain a measurable ASRT, as greater stapedial force may be required to overcome the increased variability induced by the presenting condition. The method recommended, based on the results of this study, sacrifices efficiency for stability by measuring the ASRT at ear canal pressures offset from the TPP by –50 daPa. This strategy proved successful because it provided a method to obtain ASRTs at lower sound pressure levels in individuals with high-admittance tympanograms than was possible using standard clinical procedures. A simple analysis supports this assertion. The average difference in ASRTs between groups for all participants is 3.4 dB at TPP. However, the difference in ASRTs between groups at TPP in the control group and –50 daPa (relative to TPP) in the high-admittance group is 0.3 dB. It seems clear that introducing a slight negative pressure relative to TPP in the ear canal allows for measurement of ASRTs in persons with high peak Y_{tm} that are comparable to persons with normal peak Y_{tm}. Further research is needed to determine the effect that greater degrees of hearing loss will have on the performance of the suggested protocol and whether the lower ASRTs measured within the high-admittance group are significantly better than those obtained at TPP. All of the participants with hearing loss (n = 3) in the present study had pure-tone thresholds of 50 dB HL or less at the activator tone frequencies, thereby increasing the probability of obtaining measurable ASRTs (Silman & Gelfand, 1981).

Summary

In persons with normal tympanograms, as well as those with high-admittance tympanograms exhibiting a peak Y_{tm} of >2.1 mmho, there is no significant increase in ASRTs when measurements are made using an ear canal pressure set 50 daPa below TPP. The absent ASR rate, however, is lower at this ear canal pressure. Therefore, it is suggested that clinicians modify the normal ASRT protocol for patients who have tympanograms with peak Y_{tm} values >2.1 mmho by reducing the ear canal pressure to –50 daPa (relative to TPP) during ASR testing. This ASRT should be considered valid, and the modified procedure should be noted in the clinical report.

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Contact author: Jeffrey J. DiGiovanni, School of Hearing, Speech, and Language Sciences, W222 Grover Center, Ohio University, Athens, OH 45701. E-mail: digiovan@ohio.edu.

Dennis T. Ries is currently affiliated with Ohio University, Athens.